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EFFECTS OF BLAST ON BUILDINGS

PRESIDENTIAL ADDRESS BY ALBERT HAERTLEIN,* BOSTON SOCIETY OF CIVIL ENGINEERS, MARCH 18, 1942

IN common with all citizens we as engineers are concerned with winning the war as quickly as possible. Perhaps we recognize more fully than others the efforts demanded to accomplish this purpose. Already some of our members are in the armed services performing with honor and distinction those duties which make mechanized warfare possible. The strategist and the tactician alike expect a great deal of the engineers. Other members are engaged in the stupendous task of designing and constructing the implements of war. New cantonments, military bases, airports, ships, and industries have been and are being completed in unprecedented short periods.

This war, sometimes referred to as total war, differs from previous wars in that the civilian population is subject to attack. In order to minimize the casualties and to interrupt the processes of production as little as possible the civilians are asked to seek shelter in the event of an air attack. To the question, "What are adequate and suitable shelters?", the engineer, trained in the laws of nature and familiar with the properties of materials, can help to formulate the answer.

As a member of the Planning and Technical Division of the Massachusetts Committee on Public Safety I was assigned the problem of air raid shelters. The accounts in the foreign technical press on the bombings in Spain in 1936 indicated what might occur elsewhere. An examination of several hundred buildings for the purpose of finding shelter in existing buildings during an air attack has brought forth the need for intelligent consideration of shelter requirements. Although this paper is restricted to the effects of blasts, a few comments on bombs may be desirable for a better understanding of the specific topic.

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During an aerial attack, the civilian seeks protection from (1) aerial bombs, (2) machine gun fire, and (3) fragments from anti-aircraft shells. The major requirements of a shelter will depend on the behavior of the bombs. Aerial bombs are of three general types;

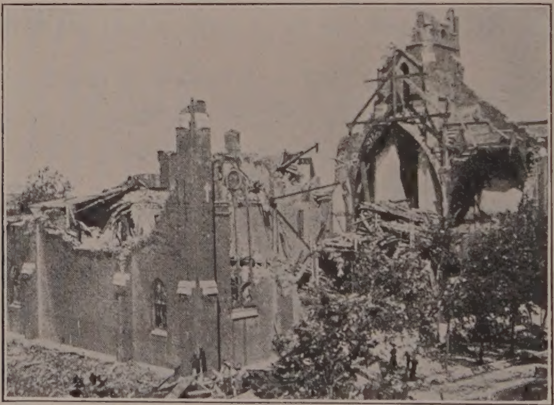

FIG. 1.—CHURCH AFTER HURRICANE, ST. LOUIS, 1896

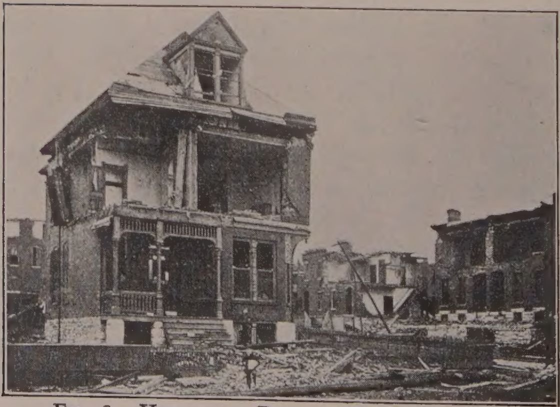

FIG. 2.—HURRICANE DAMAGE, ST. LOUIS, 1896

namely, incendiary, gas, and high explosive, including the fragmentation bombs, demolition bomb, and mines.

Incendiary bombs, usually weighing from 2 to 100 pounds, are composed principally of magnesium, thermite, oil, or other highly incendiary substances. They are used chiefly against easily inflammable targets, such as congested dwelling areas in cities. The thermite-magnesium bomb weighing 2.2 pounds, with or without an explosive charge, has been the prevalent kind and size. Such bombs

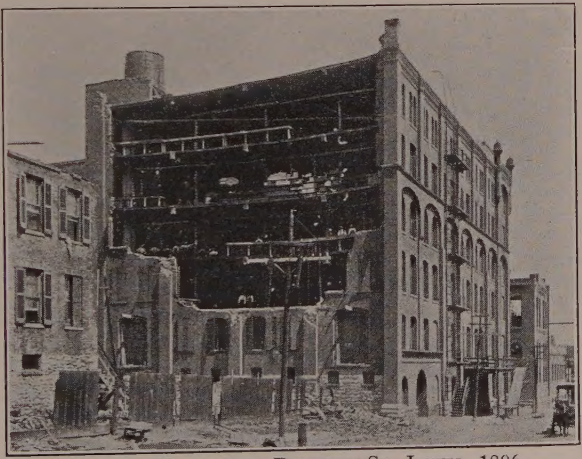

FIG. 3.—HURRICANE DAMAGE, ST. LOUIS, 1896

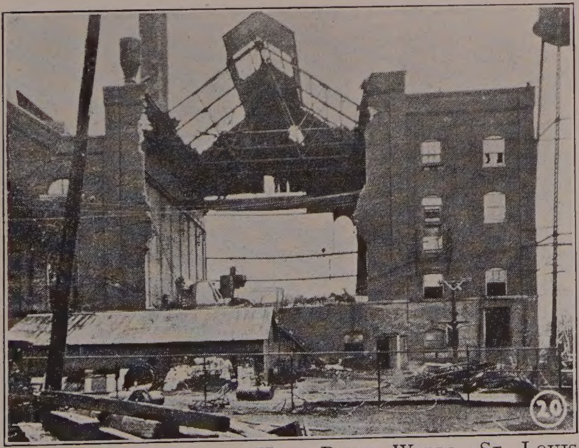

FIG. 4.—POWER HOUSE—HIGH BRICK WALLS. ST. LOUIS, 1927 HURRICANE

when dropped from an airplane will penetrate many of our roofs and under certain conditions may penetrate one or more additional floors. A concrete slab, four inches in thickness, is needed to resist penetration. Since few buildings have roofs offering such resistance, incendiary bombs may be expected to fall inside of buildings during an air attack. These bombs, containing little explosive, if any, are not accompanied by blast effects. Their purpose is to destroy through fire.

Gas bombs ordinarily do not have an explosive charge. Their purpose is to retard the activities of people. A direct hit will penetrate a building to the same extent as an incendiary bomb.

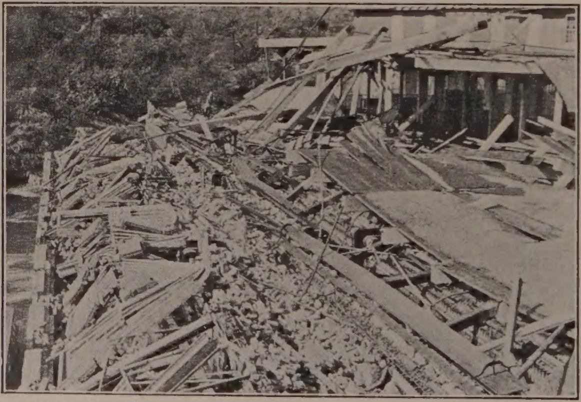

FIG. 5.—TEXTILE BUILDING DAMAGE, NEW ENGLAND HURRICANE, 1938

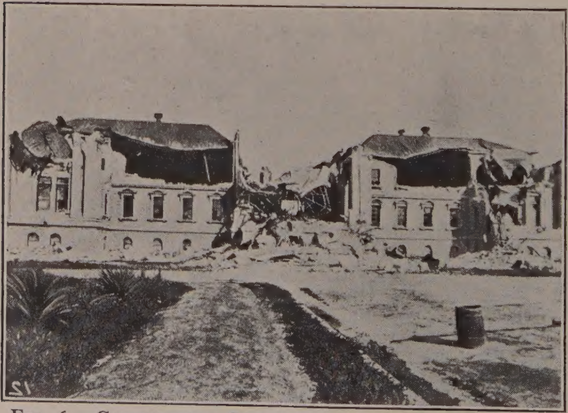

FIG. 6.—GYMNASIUM, LELAND STANFORD JR. UNIVERSITY, SAN FRANCISCO EARTHQUAKE, 1906

High explosive bombs have for their purpose the destruction of buildings and other structures. The immediate effects of such a bomb upon striking a target are impact and detonation. The impact may result in penetration, and detonation may result in blast, either a shock in the earth or a blast in the air, and fragmentation of the bomb case.

The amount of penetration of any bomb depends on its shape,

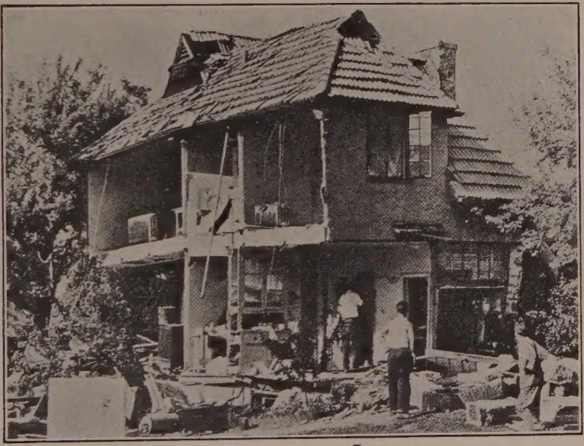

Fig. 7.—Damage by Lightning

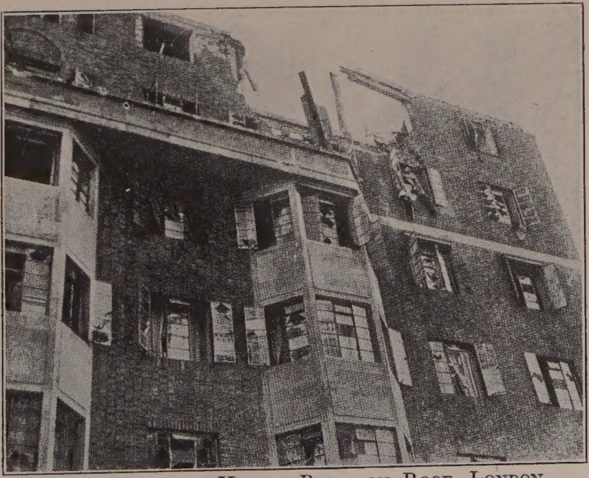

Fig. 8.—Direct Hit of Bomb on Roof, London

weight, strength of case, striking velocity, angle of impact, the properties of the materials struck, and whether it is equipped with an instantaneous or delayed action fuse. For example, a 500 pound high

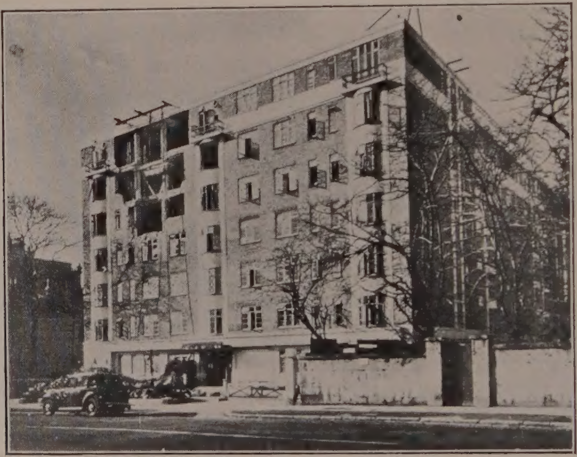

FIG. 9.—SIDE WALL HIT OF BOMB, LONDON

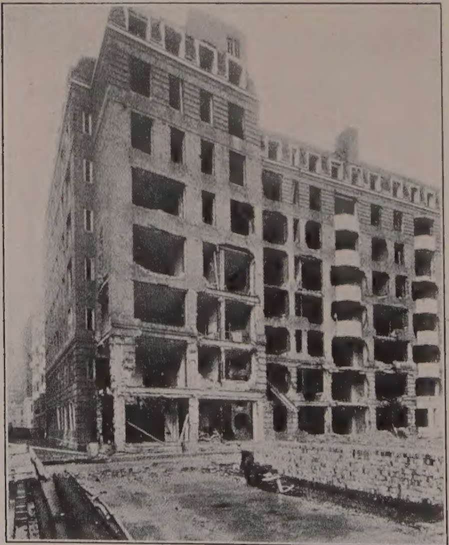

FIG. 10.—SIDE WALL HIT ON CORNER ROOM OF SECOND FLOOR; NEAR MISS IN FRONT OF SECOND BUILDING

explosive bomb may penetrate a concrete slab, 5 feet in thickness, when placed on the surface or may penetrate 60 feet of earth. It is evident that few buildings are able to resist penetration of direct hits from such bombs. It is also clear that it is not feasible to build bombproof shelters to house any substantial portion of our seaboard population. Consequently, in total war civilians must take chances of direct hits. By dispersing the population and selecting shelters to

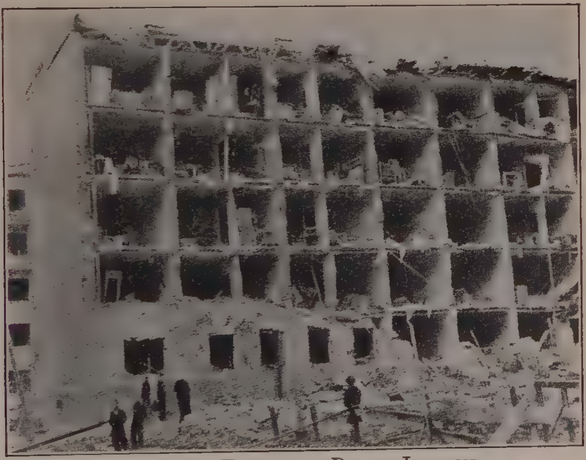

FIG. 11.—EFFECT OF BLAST, LONDON

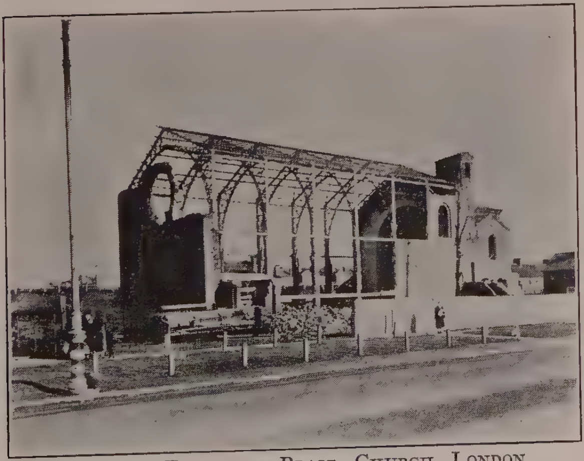

FIG. 12.—EFFECT OF BLAST, CHURCH, LONDON

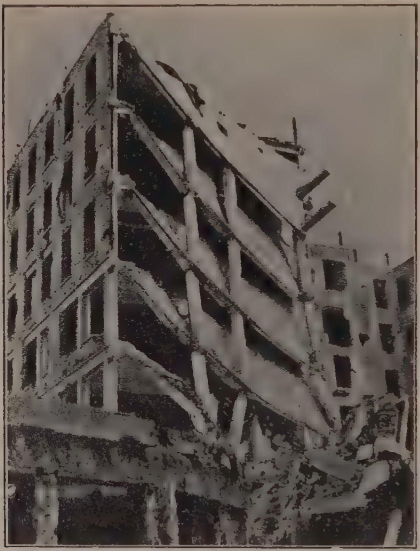

FIG. 13.—REINFORCED CONCRETE BUILDING COLUMN BLOWN OUT, MADRID

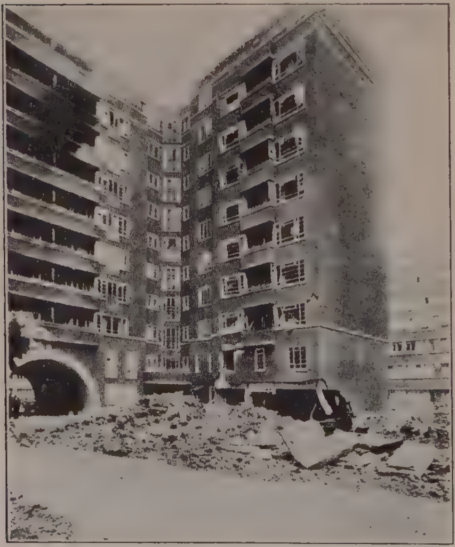

FIG. 14.—APARTMENT HOUSE, LONDON. TWO COLUMNS COMPLETELY SEVERED

minimize some of the other effects of these bombs, the number of casualties may be considerably reduced.

By blast of a bomb is meant the compression and suction waves which are set up by the detonation of high explosives. At every point in the vicinity of an explosion there occurs first a momentary wave of high pressure, and then a negative "suction" pressure. These waves exert pressures on objects which are in their path. At a distance of 50 feet from the center of the explosion of a 500 pound high explosive bomb the positive pressure may be several times atmospheric pressure. At 100 feet away the pressure may be only a fraction of atmospheric pressure. The negative or "suction" pressure is always less than atmospheric pressure.

Fragmentation occurs when the bomb case is shattered by the explosion. Splinters from the case fly in all directions with initial velocities exceeding those of rifle bullets, piercing brick and concrete walls. At a distance of 200 yards from the explosion of a 500 pound bomb, a steel plate 1.5 inches thick, brick wall 13 inches thick, concrete wall 12 inches thick, sand or earth revetment 30 inches thick would be required to resist penetration of flying splinters.

Since statistics indicate that the largest amount of damage to buildings is caused by the effects of blast, it is well to recall the experiences and lessons learned from blasts originating from other sources

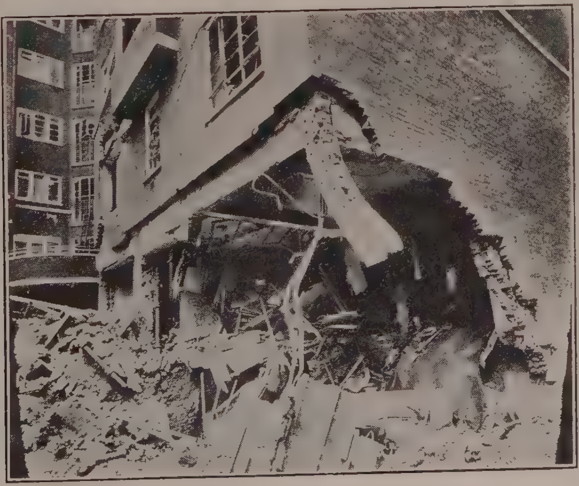

FIG. 15.—DETAIL OF CORNER COLUMN, LONDON

than explosive bombs. Engineers have been cognizant of blasts from winds and earthquakes for several decades. The failure of the Tay Bridge on the night of December 28, 1879, brought to the attention of the profession the fact that wind exerts a force which cannot be ignored in the design of structures. It is interesting to note that in 1873 when the preliminary plans were being made for the Firth of Forth bridge, Sir George Airy, the Astronomer Royal and a physicist of renown, was asked what wind force may be expected on such a bridge and he replied that 10 pounds per square foot would be sufficient. In 1880, following the collapse of the Tay Bridge, when new designs were being prepared for the Firth of Forth Bridge, he was again asked the same question and then replied that wind pressure of 120 pounds per square foot should be used. Sir Benjamin Baker and Sir John Fowler, after some experiments on flat plates, designed the bridge for a wind force of 50 pounds per square foot. The bridge is still standing. It has been the target of aerial bombardment in the early months of the present war.

Mr. Juilius Baier's paper on "Wind Pressure in the St. Louis Tornado with Special Reference to the Necessity of Wind Bracing for High Buildings"[1] emphasized the need for a consideration of wind forces on buildings. On May 27, 1896, a tornado which passed over an area of three square miles in St. Louis caused the loss of 225 lives and the destruction of $12,000,000 worth of property; 7,263 buildings were destroyed or seriously damaged; 321 buildings were totally wrecked. The maximum destruction is illustrated by the church (Fig. 1). Such instances were few and nearly always due to a collapse on account of old and weak construction. In general the damage was confined to the roofs and upper walls (Fig. 2). The effects of suction are shown in the blowing outward of the upper four stories (Fig. 3) of this building in which the walls were 13 inches in thickness on the fifth and sixth stories and 18 inches on the third and fourth. In 1927 St. Louis was again visited by a devastating tornado. By far the most complete destruction was caused by a partial vacuum inside of closed buildings (Fig. 4). Flying debris caused serious damage. A single illustration (Fig. 5) will show the effects of blast in the New England hurricane of September 21, 1938. The need for anchoring the roof was again brought to the attention of architects and engineers.

---

[1] Transactions of the American Society of Civil Engineers, Vol. 37, 1897, pp. 221-307.

For the effects of earth shocks on buildings, earthquakes afford many illustrations. In the San Francisco earthquake of April 18, 1906, much damage was caused by fire, which swept a large section of the city, but the effects of blast were observed on many buildings which escaped destruction by the ensuing fire. The collapse of brick walls (Fig. 6) caused the damage to the steel skeleton framed dome on the gymnasium at Leland Stanford Jr. University. The nearby library which also had a steel dome but supported on a steel frame carried to the ground survived.

An unusual instance of a blast is that caused by a stroke of lightning on the building shown in Fig. 7. The illustration of the effects of blast produced by wind, earthquakes and lightning bear a close resemblance to the destruction caused by high explosive bombs as illustrated in Figs. 8-15.

From a study of the effects of earthquakes on various types of buildings Mr. John R. Freeman[2] drew the following conclusions:

1. Well built structures of wood, brick, or of squared stone laid up in strong mortar have generally withstood earthquake shocks.

2. Buildings of monolithic reinforced concrete, deposited around well designed steel skeletons, have in general withstood wonderfully well the extremely severe earthquakes of Tokyo, Japan, 1923; Santa Barbara, 1925; Managua, Nicaragua, 1931; and New Zealand, 1931.

Experiences of buildings in wind storms and aerial bombardment have also shown that the framed type of building is less liable to collapse than one having load bearing walls. Damage to framed buildings can be readily repaired while a wall bearing type of building frequently becomes a heap of ruins. One may suggest that in consideration of the safety of its occupants as well as for utility, buildings intended for occupancy by groups of people, such as schools, churches, and theatres, be constructed of either steel frame or reinforced concrete frame with reinforced concrete floors and roofs regardless of height. Buildings more than five or six stories in height are now generally of this type of construction.

---

[2] John R. Freeman, "Earthquake Damage and Earthquake Insurance", McGraw-Hill Book Co., 1932.

DISCUSSION OF BSCE FLOOD COMMITTEE REPORT

By William Glenn Hoyt*

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Hydraulics Section, BSCE, held cn February 18, 1942.)

By plotting curves of the frequency with which words having different numbers of letters occurred in the works of many prominent writers, the late T. C. Mendenhall, physicist and educator, determined that each curve had characteristics peculiar to the individual author. Although such a method of analysis has not been attempted with respect to your flood report with its 30 authors, a discriminating study of it indicates that it reflects unerringly many of the excellent characteristics normally associated with New England. Many of your homes and industrial plants have been inundated three times in eleven years by floods that were supposed to happen only once in 10,000 years more or less, but even so you have not been stampeded into accepting any rule, formula or doctrine that did not conform with the facts at the disposal of your committee. Nor have you, in spite of these catastrophes, suggested in the report that the taxes on my old farm in New York State be used to defray the cost of controlling local floods in Massachusetts. Your committee has perhaps accepted the present national flood control policies, but not necessarily advocated them.

The report in many particulars reflects, and rightly so it seems to me, a condition which is somewhat difficult to express, namely, the attitude of a consultant to a private client who is directly concerned with the money involved.

A third aspect of the report might be considered. According to the Bible there are only two kinds of sins—those of commission and those of omission. You may feel as I do that it is the sins of omission which worry us most—the letters we failed to write, the flowers we failed to send and the truths we failed to utter. In some respects this is perhaps true of your flood report. Much has been left unsaid. As one of the oldest, if not the oldest, engineering societies in the United States, is it not incumbent upon you to make your report and the discussion of it all inclusive with respect not only to flood hydrology but also with respect to flood control economics and policies?

---

*Principal Hydraulic Engineer, U. S. Geological Survey, Water Resources Branch, Department of the Interior, Washington, D. C.

In 1930 your Committee on Floods was for all practical purposes the only considerable group working on hydrology in New England. During the 10-year period 1930 to 1940 there have been at least five profound changes in national water policies that have enlarged materially the scope of hydraulic engineering and hydrology in New England and elsewhere. In an article published in the Proceedings of the American Society of Civil Engineers (Feb. 1942, Vol. 68, No. 2) I have ascribed the following three reasons for the changed policies: (1) the last decade was characterized by a degree of Nation-wide abnormality with respect to floods and droughts which has probably not been exceeded during the past century; (2) the impact of an economic crisis with chronic symptoms that began in 1929 and the associated depression brought about changes in political leadership as well as modifications in governmental theory; (3) the belated Nation-wide recognition that the wastage of soil and water is a real menace to the national welfare. Directly or indirectly these causative factors resulted in new or enlarged Federal water policies as follows:

a. The initiation of land and water planning as a distinct Federal function.

b. Enlargement of the Federal reclamation idea from one of large developments on arid lands to an all-embracing use of water for irrigation on both large and small areas in which problems of population shifts and resettlement play an important part for the first time.

c. Extension of Federal flood control activities from purely navigable and interstate streams to include others which affect the general welfare regardless of the size of channel.

d. The inclusion in the Federal flood policy of so-called "upstream engineering" as an integral part of flood control operations.

e. A disposition on the part of Congress to favor actual development of hydropower by the Federal Government whether the primary purpose be navigation, flood control or reclamation.

Largely as a result of these changed policies the amount of Federal money expended annually on measures and practices designed to change the runoff phase of the rainfall-runoff cycle has increased from some $30,000,000 in 1930 to almost a billion dollars in 1940. Directly related thereto is the greatly expanded Federal activity with respect to the collection and analyses of basic hydrologic data in New England. Aside from what may be called the normal and continuing functions of the Weather Bureau with respect to the collection of meteorologic data and of the Geological Survey with respect to stream flow and ground water stages and quantities, which activities have increased somewhat as a result of the new policies, the expanded activities embrace primarily: (1) Studies and analyses by the U. S. Engineer Department in connection with its all-embracing flood-control program; (2) Increased activities of the Weather Bureau in connection with its flood forecasting problems and perhaps more especially, its synoptic analyses of outstanding storms and its special meteorologic studies for determining limiting precipitation rates; (3) Studies and plans of the Federal Power Commission in relation to the coordination of power and flood control; (4) Investigations, studies and plans of the Department of Agriculture through the Forest Service, Soil Conservation Service and the Bureau of Agricultural Economics to determine the degree to which flood damages may be alleviated through changes in land practices and upstream engineering; (5) Planning activities by the water and land committees of the National Resources Board; (6) Statistical studies and research by W. P. A. groups sponsored by State or Federal agencies; and (7) Compiling, analyzing and publishing basic data by the Geological Survey concerning certain outstanding floods in greater detail than is customary in its routine stream flow reports. Although these expanded activities have been extensive it is creditable that generally they have been well coordinated through cooperation and collaboration, thereby reducing duplication to a minimum.

Based on a most general knowledge of the scope of these various activities I have estimated that during the 11-year interval between your two flood reports more than one million man hours have been spent in collecting and analyzing meteorologic and hydrologic data pertinent to New England, most of which related directly or indirectly to floods. This is equivalent in time to continuous work by your committee of 30 for 40 hours a week over a period of 15 years. Whereas your 1930 committee was working in practically virgin territory your 1940 committee surveyed a territory that had been widely explored and somewhat over-trodden in places.

Under the circumstances described, your committee has compiled from the mass of available information certain fundamental data which describe the outstanding floods—their causative features and resulting damages; it has outlined the principal engineering features having to do with their control and forecasting; it has reviewed some of the modern concepts of hydrograph analyses; has pointed out the general adaptability of the "flood characteristic hydrograph" as first introduced by the 1930 committee and compared it with the unit hydrograph; and has further developed hydrologic technique by presenting another method by which a given storm pattern may be translated into a flood hydrograph.

A little later I wish to discuss features of the report, my present concern is more or less related to an over-all problem which your Society is peculiarly fitted to consider. I believe that as a society you have fewer axes to grind than any other similar organization. Your homes and activities are in a region noted for rugged individualism and no society can justifiably claim to be composed of abler members. Under these conditions I believe the engineering profession might well look to you for a more thorough survey and appraisal of many of our present concepts of flood hydrology and policies than is contained in your present flood report. It isn't because there are not enough hydrologists working on various problems that I say this. In 1917 when Adolph Meyer first published the "Principles of Hydrology" I dare say there were no more than 25 engineers devoting their full time to hydrologic problems. Today, I surmise that well over 1,000 are devoting full time to problems relating to the occurrence, use and control of water. Each of these, like the blind men, has approached the elephant from a different direction. Each has built up certain concepts depending on what part of the elephant came within his scope. The time is opportune for an appraisal of the hydrology and policies back of our multitudinous activities designed to prevent floods, alleviate droughts, retard erosion, conserve water supplies, provide an ever-normal granary and other activities designed to stabilize our economy with respect to climate, which taken by and large is a sizable elephant.

As an employee of an old established Government organization it is not my function to discuss questions of policy. I can, however, discuss with propriety some puzzling flood phenomena which have come to my attention and perhaps point out difficulties inherent in studies of flood hydrology in other parts of the country as compared with New England conditions. Probably in no other section of the country is there as much comprehensive and intensive information available per unit of area concerning all phases of floods as in New England. Your records embrace almost every possible combination of condition ranging from the most favorable in so far as natural storage is concerned, such as existed at the beginning of the storm of September 1932, to the extraordinarily adverse, as they related to snow such as was present during March 1936 or as they related to storm intensities during the two unusual autumn storms of November 1927 and September 1938. Your committees working on flood problems do not therefore have to delve too greatly into the unknown or extrapolate their deductions too far. For example, your flood report calls attention to deficiencies in precipitation records in New England. In contrast I wonder how your Committee would react if it were confronted with the task of analyzing major Texas floods, as recently as those which occurred during 1936, and found that wide areas in that State larger than the entire State of Massachusetts were not provided with a single official rain gage. Consider also please that no matter how you array the values of known maximum flood runoff rates in the United States, Texas like Abou Ben Adhem leads all the rest, and almost yearly its hurricane storms bring floods that startle even flood-control experts.

Although you may have to take off your hats to Texas and some other parts of the country with respect to the magnitude of instantaneous rates of flood discharge you can contend for high precedence in respect to total flood volumes which are generated in New England by warm rains and melting snow—Nature's Double Zero. Broadly speaking, volumes of flood runoff in individual floods in New England are rarely exceeded except in parts of the Pacific Northwest.

A rather hurried review of some 4,000 flood events for which records are available in the North Atlantic Region indicates that the flood runoff from the drainage basin of the East Branch of the Pemigewasset River above Lincoln, N. H., during the flood of March 1936 sets the outmost limits of an enveloping curve of flood runoff for the entire area tributary to the Atlantic Ocean from Maine to Maryland.

During this flood period the volume of runoff was approximately 4 inches for one day; 15.4 inches for 10 consecutive days; 17.4 inches for 15 consecutive days; and 25.8 inches for 30 consecutive days. When flood runoff accumulates in river channels at the rate of over an inch a day for 15 consecutive days, as it has done in several basins in New England, flood problems are bound to be acute and their control or alleviation most difficult. Although a little later I wish to discuss briefly the subject of forests and stream flow, it is perhaps somewhat ironic that the maximum flood runoff of record in the broad area between Maine and Maryland should have occurred in a rugged, forested drainage basin in which I am advised there is but little cultivation and which generally has not been greatly modified by man's activities.

Several other comparisons may be interesting. Generally speaking drainage basins of New England are relatively small and, although you may not so consider them, they are, aside from the coastal plains, comparatively speaking homogeneous as to soil, cover, topography, aspect and altitude. Rainfall and runoff records which have been analyzed with respect to your major floods support the observation that during the major flood periods the effect of physiographic and edaphic conditions are nearly uniform throughout much of New England. I can cite many examples of broad areas where such conditions do not prevail. For example, during December 1937 a major storm of Pacific origin swept inland across California in much the same way as do the Atlantic hurricanes on the East Coast. This particular storm covered some 109,000 square miles of area, embraced a coastal plain, two mountain ranges and a great central valley. One basin which is typical of much of the area is the 1,000 square miles lying on the slope of the Sierra Nevada embracing Yosemite National Park. The difference in altitude in the Merced River drainage basin above Exchequer, Calif., is from 400 feet to over 13,000 feet. This altitude range results in a series of zones in the basin varying from semiarid to humid and from subtropical to frigid, each with its own soil, vegetative cover and physiographic features. To a greater or less degree many of the sub-basins making up the combined Sacramento and San Joaquin drainage basins and other major basins of the West include similar wide ranges in soil, vegetative cover and physiographic features.

Rainfall-runoff analyses and interpretations thereof during flood periods are extremely difficult in such areas. For example, abnormality of only 8 degrees during the December 1937 storm had the effect through its influence on rainfall characteristics of adding 12,000 square miles or 1½ times the area of Massachusetts to the area, therefore receiving rain instead of snow and so contributing flood runoff to the San Joaquin and Sacramento Rivers. As to altitude effect, your report shows some slight orographic effect during the storms analyzed. Many of the mountain ranges of the West are the "authors of their own weather" and during the California storm just outlined the storm precipitation varied from 2 to 22 inches largely as a result of orographic influences, storm intensities being modified but little by frontal action.

One other feature typical of much of New England, which may make your task of analyzing flood runoff perhaps less difficult than in some other parts of the country, relates to the small amount of natural storage which is here interposed between rainfall and runoff. During outstanding storms in this region, speaking generally, the net difference between rainfall and runoff is so small that for most practical purposes your task is one largely of shaping up a pluviograph of the total precipitation into a 100 percent hydrograph of runoff. I believe published records will support my observation that with few exceptions the major floods in most of the East have been associated with major storms. In other words, there is some direct relation between inflow in the form of rain and melting snow and outflow in the form of flood runoff. The reverse of this condition seems true in much of California, for example, and perhaps in many other areas of the West. In many of these areas the amount of natural storage interposed between rainfall and runoff is probably between 5 and 10 times the amount of natural storage in many headwater basins in New England and is believed to approach 15 to 20 inches in some localities. Under these conditions the amount of flood runoff is more often related to the amount of antecedent rainfall and its effect on natural storage than it is to the immediate storm which produced the flood.

One other feature that may simplify your analyses or at least simplify your flood problem as a whole is that your basins are small, your flood largely a translatory flood wave, and your flood runoff reaches the sea quickly. During the flood of March 1936 roughly 20,000,000 acre-feet found its way to the sea through the eight main river channels of New England and approximately 15,000,000 acre-feet reached the sea through other smaller streams.

During the storm and flood of January 1937 in the Ohio River Basin, 90,000,000 acre-feet of water or nearly three times the amount involved in all New England had to flow out of the Ohio Basin through a single river channel at Cairo, but not until it had flooded a natural reservoir provided by that channel having a capacity of about 38,000,000 acre-feet, representing storage 22 times greater than all the total storage capacity in the 21 reservoirs in New England listed in your report.

One other point of interest with respect to the great Ohio flood of January 1937 is that during the storm period few, if any, flood records were broken in the individual basins making up the Ohio River Basin. The combination of five nearly distinct storm periods following one another in close succession resulted in inflow into the Ohio River channel from Pittsburgh to Cairo faster than it could be discharged at Cairo, with the result that stages and discharges exceeding any within historic record were built up in the main channel. During the height of the flood period water was flowing into the Ohio River channel, submerging farms, towns and cities at the rate of five million acre-feet a day, or enough to have filled Lake Mead, the largest reservoir in the world, in one week, whereas with the entire flow of the Colorado River being impounded it takes two years to fill the reservoir. I do not wish to convey the impression that "colossal" can only be used with respect to California and Ohio conditions. Your floods of March 1936 and September 1938 are certainly entitled to the rating of "stupendous." Geological examination of flood deposits in New England has indicated that floods of the magnitude of March 1936 have probably not occurred in the Connecticut River Valley since at least 300 years before the landing of the Mayflower. One outstanding difference between the two floods of historic record in the Ohio and in the Connecticut River valleys is that the Ohio River flood was a main channel flood and damage resulted largely from submergence, whereas during your major flood periods records are broken in all parts of the basin and damages result not only from submergence but also from dynamic action.

I have outlined only a few of the differences in flood behavior resulting from differing physiographic and edaphic conditions. Partly on account of these differences in flood behavior we have various schools of thought with respect to flood hydrology. It is toward analyzing some of these differences that I would direct the attention of your flood committee.

I have been asked by your president to make reference to observations made during the outstanding storm and flood of March 1938 in southern California. In two days about 25 inches of rain fell on the steep slopes of the San Gabriel and San Bernardino Mountains, tributary to the coastal plains on which the City of Los Angeles and adjacent communities are situated. Observations of runoff from small plots so located as to be typical of much of the contributing steep mountainside indicates less than .20 inch of surface runoff from over 25 inches of rain. In other words, practically 100 percent infiltration took place with little surface runoff. However, in spite of the plot indications of no appreciable surface runoff, within four hours of the height of the storm much of the coastal areas was inundated by a flood which took a toll of about 100 lives and caused property damage estimated at 87 million dollars.

I have not had access to the results of any infiltrometer tests or other studies of surface runoff, which may have been made in New England. The following observations with respect to natural storage, flood runoff and infiltration capacities are based necessarily on the rainfall-runoff analyses published in Water-Supply Papers 798 and 867. Although these results are averages for complete drainage basins and do not show surface runoff or storage characteristics under the differing soil and cover complexes of this region, they do indicate it seems to me three facts pretty clearly, namely, (a) that during major floods in New England the total amount of natural storage, transpiration and evaporation interposed between rainfall and channel inflow during your major flood periods may be in the neighborhood of only 1.5 to 2.5 inches as was the case during the floods of March, 1936; (b) that average infiltration indices even with no frozen ground are pretty low, ranging between .02 and .20 inches per hour as shown by the analyses of the hurricane storm and flood of September 1938, and (c) that the average infiltration indices tend to increase downstream, being a minimum in headwater basins and a maximum in coastal areas. These conditions seem radically different from the conditions described in California. Major floods have occurred and will continue to occur, however, in both localities. The New England conditions described make a study of flood hydrographs and flood routing more simple than if there were large amounts of natural storage involved. On the other hand, absence of large amounts of natural storage must it seems to me make difficult the task of those who would materially change flood characteristics on many New England streams by measures other than large engineering structures. In this connection your flood committee makes no mention either one way or another of the radical change in Federal flood policy since the first flood report was written, namely, the inclusion of land management and upstream engineering as an integral part of the Federal flood control policy. It would seem almost an omission by your committee not to include some discussion of these new activities in your chapter on "The flood control programs and work."

One of your committee members has asked me to discuss a ticklish subject, namely, the relation of forests to floods. So far as I know, no studies have been completed showing changes in New England which may be expected in flood stages as a result of changes in land management. If my memory serves me correctly, in a paper delivered at the hydrologic conference held at Penn State last July conclusions based on incomplete studies indicated that, following adoption of proper land use management in the Connecticut River Basin reductions in flood volumes up to 25 percent might be expected during late spring, summer and fall floods and 10 percent reduction in winter floods.

Results of controlled experiments on the Appalachian Forest Experiment Station in North Carolina, reported at the Penn State Conference, showed that in the first 12 months after all tree growth had been cut there was increased stream flow of some 17 inches in depth on the cut-over basin. This forest experiment station is in a high rainfall belt and geologic and soil conditions are far different from those in New England. In the North Carolina area the annual use of 17 inches of water by forest growth, when coupled with the high infiltration capacities, provide an enormous agency for disposal of flood waters which might not be available if the trees were removed. On the other hand when storage of water is desired for municipal use, the large use of water by trees must be weighed against such benefits to flood control as may be derived through their removal of water from or drying out of the soil. At some 125 places throughout the United States Federal agencies are conducting research activities to determine the intricate relations between rainfall, runoff, soil moisture, and soil movement under different climatic, physiographic, and geologic conditions and the effect of cover and land use on such relationships. On the basis of observation at these experimental areas your committee should be able to reach reasonable conclusions applicable to New England conditions.

Reverting to the flood report, your 1930 committee first called attention to the fact that the base of flood hydrographs at any point on a stream for storms within the "concentration period" had substantially the same length regardless of the amount of flood runoff. Somewhat prior to 1930 the late Professor John F. Hayford through a rigid mathematical analysis showed that it was possible to determine for any basin where the precipitation exceeded 20 inches annually, some 25 constants and coefficients whereby there could be computed not only the base flow but also the flood runoff. It has always been a source of regret to me that Dean Hayford passed away before he could apply the results of his extensive studies to an eastern stream. He estimated that it would take 200 days to determine the coefficients for any one basin. No one, as far as I know, has attempted to apply Professor Hayford's methods to the development of a flood hydrograph. The methods are unquestionably formidable but they have in them all the elements from which graphs by any name may be obtained. They are perhaps as modern, if not more modern, than some of our present "tools" but they have the disadvantage that they are not either easily understood or readily workable. While on the subject of hydrographs, I think we might just as well be frank and admit that there are features regarding flood hydrographs and unit hydrographs that are as puzzling now perhaps as they were in 1934 when with the advice of six experts I made certain studies of rainfall-runoff relations that were published in Water-Supply Paper 772. Studies such as your committee has made and I hope will continue to make will do much to clear up some of these points.

Your committee presents a method for derivation of flood hydrographs which applies ingenuously the recession curve as a measure of storage characteristics of a basin. This principle was first suggested, as you state, by Dr. R. E. Horton and has been applied by W. B. Langbein, my immediate associate, and others. This concept has provided engineers with a comparatively simple yet powerful tool whose usefulness in application to practical work has yet to be thoroughly explored. As a part of its analyses of major floods, the Geological Survey used this principle to evaluate storage as such, without specific reference to development of flood hydrographs since the unit hydrograph seemed to supply this need. The Survey also explored the application of the recession curve to analyze flood hydrographs in order to derive hydrographs of channel inflow for comparison with precipitation and in computations of initial abstraction. Recently it has been shown by Langbein and others that the three tools, namely, the channel storage curve, the lag time and the unit hydrograph are intertranslatable and methods have been outlined for computing the lag from the recession curve and for deriving a unit hydrograph.

A real present difficulty facing engineers is how to explain the differences found between different floods on the same streams. Any differences in the unit hydrograph derived from different floods will be explained in corresponding differences in the recession curve of storage or in the lag, providing the same degree of refinement is used with each. None is any more conservative than the others. Large basins which still act as a unit are more conservative in this respect than small ones. The technique proposed by your committee should be tested on small as well as large basins. Many research workers have pointed out that distribution graphs derived from large floods are sharper than those derived from small floods. Additional research is needed to determine reasons for the differences in order that necessary adjustments in units hydrographs may be made.

Before closing it might not be inopportune to inject some thoughts which have been raised by my associates. With respect to the discussion of flood routing it has been suggested that the values of flood routing coefficients compiled by the U. S. Engineer offices at Hartford and Boston will be an important contribution. It has also been brought to my attention that all phases of the flood routing problem are probably not as satisfactory as the committee implies. Your studies of flood frequencies are especially significant and are a distinct contribution to the subject. They show the great uncertainty about the exact magnitudes and frequencies of major floods. Nevertheless, economics force the use of magnitude-frequency relations, even though our knowledge of them is unsatisfactory because of the shortness of available records.

The general conclusions and recommendations of your committee with respect to flood forecasting and flood warnings were written prior to the declarations of war. In the 9 months ending March 1941 defense contracts and certified plant expansion in the New England States approximated $1,500,000,000. They are probably much greater now. Unfortunately for the producer of hydroelectric power, but fortunately from the viewpoint of flood possibilities, there is as yet no change in the general weather pattern which has existed for over a year, namely, wet in the West and Northwest, unusually wet in the Southwest and Middle West and dry in the East. I assume no one knows why this particular pattern has existed for more than a year. I raise the question, whether or not if the recent persistent behavior changes, the more or less informal arrangements for the dissemination of flood warnings and flood information which your committee concludes are satisfactory for normal conditions will be sufficiently effective to protect industrial New England adequately at a time when every hour's delay in war output will be vital.

As I have said before, I wish to say again that in many areas the flood problem will not be entirely solved until our citizens recognize that Nature designed and formed river channels, valleys and overflow areas for the temporary storage and passage of flood waters. As long as man continues to use and occupy these channels and flood plains for homes, farms, highways, communities and cities, flood damage and loss of life will be inevitable. In such areas quick, accurate and dependable flood forecasting offers one of the principal aids in preventing loss of life and property damage.

In closing these rather rambling remarks, I wish to state that I have considered it a great honor to be invited to appear before your Society. In any statements I may have made, my desire has been not to discourage but rather to stimulate further analyses and evaluations of floods, and it has been toward that end that my remarks have been directed.

DISCUSSION. By Howard M. Turner.*—Before discussing Mr. Hoyt's paper, I want to express to the Society as Chairman of the Flood Committee my regret that you did not get your printed copies of the report sooner, so that you would have had more time to look them over before this meeting. The only reason you did not get them sooner, I am afraid I shall have to say, is because we didn't get them ready sooner.

I want to take this occasion to thank all the members of the Committee for the work that they have done on it. So often the Chairman of a committee has to do most of the work himself. This has not been the case with this committee and the report is the result of the work of the whole committee. I won't attempt to discuss any sections of the report in detail. I hope that certain other members of the Committee will tell of the special parts in which they have been interested.

Mr. Hoyt's paper was certainly of great interest to us whose principal experience has naturally been in New England. The contrasts in flood conditions which he described were of very great interest. He is certainly correct in saying that we are fortunate in the detailed information which we can get on our floods. When he describes a condition in Texas where an area larger than Massachusetts has no rainfall gage, it makes it appear that our request for more rainfall gages requires considerable nerve. Then too, we are, of course, equally fortunate in having such long term records of our rivers and floods. We probably take these benefits too much for granted.

I was very much interested in Mr. Hoyt's discussion of our report, particularly of our sins of omission. Before I go on to his description of them I want to add one more omission of my own, which may require some explanation that is, the absence of any section dealing with high water due to ice jams. We have had some serious damage from ice jams, in 1936 and at other times, and I think some of the Committee know a good deal more about ice jams, their cause and behavior, than formerly. Unfortunately, this question of ice jams has become a subject of controversy and suits for damages, so that in view of the position of many of our Committee members in such damage cases it was decided to omit any reference to it except in descriptions of the floods.

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Another item is also mentioned by Mr. Hoyt, that is, the omission of any reference to the effect of forestation on flood flows. We did not seriously attempt any work along these lines, although at one or two of the meetings it was informally discussed. There may be data on this in New England, but I do not know of any yet published. I do not know how all the members of the Committee feel about this subject. If I could judge by the random remarks I have heard, I should say that most of them would feel as I do, that is, that it is doubtful if any program of forestation, however extensive, would have a very marked effect on the flood flows of our New England rivers. The Harvard Forestry Station has some interesting models of which I have seen pictures, showing the evolution of a piece of New England landscape starting with its primeval forest, then cleared, first probably for cultivation and later for lumber and then as the tide of farming in New England reduced, growing up again to another forest. I do not believe there is any question whatever, but what the drainage area of the areas of the Connecticut and Merrimack rivers now have more forest cover than they had fifty or a hundred years ago. On the Connecticut three of the big floods of the last three hundred years, including the very largest, have occurred within the past fifteen years. I think this is a very fruitful source of investigation, though I must confess it seems to me it is going to be difficult to get adequate data from which to draw conclusions. We can determine the effect of forestation on the total runoff, on the minimum runoff and on the normal flood runoff. I should think it would be very difficult to get any conclusive evidence as to the effect of forest cover on major floods.

The chief omission which Mr. Hoyt mentions, is that we have not discussed to any great extent flood control economics and policies, particularly those of the federal government. He is good enough to say that we are a society of "able men," but he also says that we live in a "region noted for rugged individualism." This committee represents many points of view including as it does army engineers, engineers with other federal and state departments, with water power and public utility companies, and consulting engineers and teachers. This subject which he would have us discuss in the dispassionate way which he apparently looks for, is laden with dynamite when presented to our body of rugged individuals, for he includes in this list of policies federal land and water planning, extension of federal flood control and the development of hydro-electric power by the federal government. These are extremely controversial subjects. When the subject of federal flood control first came up some members wanted the Committee to get behind the flood control project then proposed without thoroughly investigating it. There were others who, I am sure, thought that any of the federal flood control plans were unjustified and uneconomical. Our first report to the Society was that we had discussed the subject of federal flood control, and even if we had been able to agree on it, we did not think it was advisable to make any statement.

There is one omission for which I am sorry and that is that we did not, except by general implication, contrast the kind of flood data that we had available for these last floods with what we had available ten years ago. A great amount of credit for this, I think, should be given to the United States Geological Survey district offices, particularly the Boston office under Mr. Kinnison. To be able to get complete, accurate data, including hydrograph tables on all the flood stations in New England, has added immeasurably to the clarifying of the flood problem. And this same omission should be extended to apply to all the investigating work, the collection of data and research being done by the various federal offices in connection with the hydrological and flood control work stimulated, as Mr. Hoyt points out, by the depression and the rather extraordinary natural weather conditions.

When the Committee was formed, some of the members had doubts whether, in view of these thousands of man-hours that were engaged, chiefly by the government, in making flood studies and research, a body of busy men in their spare time could make any contribution that would be worth anything towards our flood problem here in New England. I think Mr. Hoyt has paid us a great compliment in the interest he has expressed in our report, his chief objection being to omissions of subjects on which I feel clear no committee made up like ours could have agreed.

CRACKING OF CONCRETE

BY ROY W. CARLSON*

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Designers Section, BSCE, held on January 14, 1942.)

CONCRETE develops cracks most often due to its tendency to contract when not permitted to contract freely. This paper concerns mainly the cracks due to shrinkage from drying. Cracks due to temperature effects, to applied load, and to expansion, either from unsound cement or from unsound combinations of cement and aggregate, are not considered.

Drying shrinkage contributes to the cracking of nearly all concrete, but it becomes of major importance in thin sections and in dry climates. In moist climates it is a factor in indoor concrete. It is less of a factor in massive sections and in structures exposed to damp climates. It is often true that drying shrinkage alone or temperature change alone would not cause cracks. In thin sections, drying shrinkage often needs the help of a quick temperature drop to start cracks, while in thick sections, the temperature change often needs the help of a surface drying to start cracks.

It should be recognized from the outset that the tendency of a concrete to shrink and its tendency to crack are not synonymous. Concrete with the highest free shrinkage is not necessarily the most likely to crack, because the free shrinkage is only one of several factors determining the tendency to crack. This will be more clear when translated into engineering terms.

The concrete cracks when the tensile stress exceeds the strength. The stress is the product of the three terms free shrinkage, effective modulus of elasticity, and degree of restraint, which terms are defined as follows: The free shrinkage is the amount the concrete would contract under the same conditions of mass and exposure if it were free; it is measured on unloaded specimens subjected to the same drying conditions as the structural member in question. The effective modulus of elasticity, also called "sustained" modulus, differs from the ordinary modulus only in that it includes the plastic flow; it is the stress divided by total strain, including creep. The degree of restraint is the percentage of the free shrinkage that is prevented; thus if the concrete would like to shrink 100 millionths per unit of length but is only permitted to shrink 20 millionths, the degree of restraint is 80 per cent. The restraint arises from many different sources. Perhaps most common is concrete cast on a foundation, in which case the foundation tends to hold the concrete from shrinking. But even in such a case, the restraint is seldom 100%, because even the best foundation is elastic and always yields somewhat. Another type of restraint occurs when a mortar topping of high-shrinkage characteristics is bonded to concrete. The underlying concrete then restrains the mortar from shrinking freely, and it must crack. The extensive cracks in the floors of the Massachusetts Institute of Technology are a good example of a high-shrinkage top course on a more-sound slab of concrete. Even in concrete of uniform composition, the drying usually penetrates only a few inches, with the result that the underlying concrete restrains that at the surface and so-called pattern cracking results.

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An example may help to visualize the stress development in concrete due to shrinkage. Suppose that a certain portion of the concrete in a wall on a rock foundation had a tendency to shrink, or a *free shrinkage*, of 300 millionths under the actual conditions of exposure. Suppose further that it were found that the concrete actually contracted 150 millionths at the point in question, meaning that the degree of restraint was 50 per cent, a reasonable value for the concrete a short distance above the foundation. The stress is then the force required to stretch the concrete from the short length corresponding to its desired contraction of 300 millionths to the not-so-short length corresponding to the lesser contraction which is permitted. Suppose that the effective modulus of elasticity is 2,000,000 p.s.i., a reasonable figure for concrete which has an ordinary modulus of 3 to 4 millions but in which the stress develops over a number of days and the concrete is partially dried. The stress is then 300 p.s.i., which is the triple product of 300 millionths by 50% by 2 million. Such a stress would not be likely to start a crack in concrete, because recent tests indicate the tensile strength of drying concrete of good quality to be about 500 p.s.i. It is the stress due to shrinkage alone. The effect of applied load and of temperature generally must be added to obtain the true stress.

Bearing in mind the difference between tendency to shrink and tendency to crack, more progress has been made in ability to prevent cracking than in reducing free shrinkage. The possibility of preventing cracking is far greater than the possibility of preventing shrinkage, or even reducing it materially. Shrinkage has been studied intensively for many years with the constant hope of controlling it. And yet, after making thousands of tests and trying hundreds of modifications and additives, the results have been disappointing. Much has been learned about shrinkage and consequently cracking often can be prevented, but not through any material reduction in free shrinkage of the concrete itself. There is seldom any condition to be fulfilled in designing concrete for low shrinkage that would not be fulfilled for other reasons. In general, concrete which gives the best quality consistent with economy also gives lowest shrinkage. Above all, a minimum amount of mixing water is desirable. Next in order of importance for producing low shrinkage are large maximum size of aggregate, low air voids, and sound aggregate. Contrary to expectations, reducing the cement content does not reduce the shrinkage materially, nor does a long preliminary period of moist curing do more than delay the shrinkage without reducing the ultimate amount. Likewise, the application of any except some rather unsightly curing compounds to the surface merely delays the shrinkage. Fortunately, however, several factors do affect the tendency to crack even though they may not affect the ultimate free shrinkage.

PRESENT KNOWLEDGE OF CONCRETE SHRINKAGE

A review of some of the findings to date about concrete shrinkage is necessary to provide a clear picture of the various stresses leading to cracking.

After cement has hydrated, it consists partially of crystalline centers that are believed to be immune to the effect of ordinary drying. The crystalline centers are mostly less than 0.001 inch in diameter and are made up mainly of the unhydrated remainders of cement grains and of calcium hydroxide crystals that are a by-product of hydration. The remainder and by far the largest proportion of the hydrated cement is gelatinous material, which is finely porous and susceptible of large volume changes upon wetting and drying. The gelatinous material is not, however, like gelatine, but it has a strong frame structure that is not collapsible; it merely swells or contracts as the water enters or leaves its pores. In ordinary concrete, the hydrated cement, which is mostly gel, makes up about 25 per cent of the volume. This is a natural result of the fact that practically all of the space originally occupied by mixing water and part of the space occupied by the original cement grains is replaced by hydration products. It follows that the more mixing water used, the more shrinking material is produced and the greater the shrinkage.

The shrinkage in length of the pure gel of Portland cement due to drying is estimated at well over 1 per cent when dried in air of average humidity. If the water cement ratio is very high, the gel will be of coarse texture and such gel may have a drying shrinkage of several per cent, although it has not yet been possible to produce specimens of pure and uniform gel so as to measure its shrinkage.

The crystalline centers in hydrated cement restrain the shrinkage of the gel in neat cement paste and reduce it materially. Likewise, the aggregate particles further restrain the shrinkage of the cement paste in concrete, so concrete shrinkage is only a small fraction of that of the gel. Roughly speaking, cement paste in the range of water cement ratios employed in concrete will shrink in air to about half of one per cent in length, and concrete will shrink about one-tenth this amount, or 0.05 per cent in length. The fact that concrete shrinks only about one-tenth as much as the cement paste it contains does not seem to be consistent with the facts that about one-third of the concrete is cement paste, and the aggregate is shrinkage free. One might reason that the concrete should shrink about one-third as much as the paste. But if a cross section of the concrete is studied, it may be seen that paths can be drawn almost straight from end to end along which less than one-twentieth is cement paste. The aggregate along such paths simulates reinforcing rods in restraining the shrinkage. Along such paths, both the aggregate and the separating films of paste must be under compression, because the observed contraction is more than the computed average free shrinkage of paste and aggregate along the paths. Nearly straight paths also can be drawn on the cross section along which the material is mainly cement paste. Along such paths the computed average free shrinkage of paste and aggregate would be very much higher than that of the concrete as a whole. Along such a path there must be very high tension and, in all probability, some small cracks. Thus, what we have defined as free shrinkage of drying concrete is not really free, but comprises local stresses of tension and compression, both in the cement paste and in the aggregate. This is important in trying to explain many behaviors of concrete, especially the greatly increased plastic flow of dry concrete as compared with moist concrete.

Most aggregates do not change in volume appreciably upon wetting and drying. There are exceptions, however, and those aggregates containing slate, shale, or sandstone usually exhibit some shrinkage upon drying. Some widely used aggregates are in themselves responsible for about one-third the total shrinkage of the concretes in which they are used.

The effect of fineness of cement on shrinkage of concrete is a controversial subject. In most tests, fineness of cement has been found to have no large effect on shrinkage, while in a few tests, finer cements have exhibited greatly increased shrinkage. The seemingly contradictory results are explained by different degrees of internal cracking, depending on strength and plastic flow as well as on tendency to shrink. It is believed that finer cements truly produce greater tendency to shrink, but the resulting cement paste which fills the space between aggregate particles is more brittle (less plastic flow) and thus the observed "free" shrinkage is not necessarily increased for the finer cements.

Similarly, the effect of richness of mix, or cement content, is not large. Both rich and lean mixes require about the same amount of mixing water per cubic yard of concrete when both are properly proportioned and of equal consistency. Therefore the volume of hydrated cement is about the same in either. The free shrinkage of the hydrated cement in the lean mix is greater but the paste is weaker and has greater plastic flow, so it is restrained more effectively by the aggregate. Thus, the net result is about equal shrinkage for rich and lean concretes. A word of explanation is necessary here to make this conclusion consistent with common sense. Due to the fact that neat cement shrinks many times as much as does concrete, it appears logical to conclude that rich mixes must shrink more than lean mixes. But, in addition to the water cement ratio being lower in rich mixes, the gradation of aggregate varies with the richness of mix. Coarser gradation is advantageous and customary for richer mixes. Thus the spaces between aggregate particles are about the same for rich as for lean mixes. Under practical conditions, then, rich mixes do not show excessive shrinkage. When the cement content is increased so much that the coarsest possible gradation of aggregate is not as coarse as that dictated by design, then an abrupt change occurs and the very rich mixes shrink more as might be expected.

Larger aggregate is quite effective in reducing shrinkage of concrete. A part of the effect is attributed to the lesser air entrainment in concretes containing larger aggregates. Another part of the effect is due to the lower water contents permitted by the larger aggregates. But an important effect of larger aggregate is to promote internal cracking between particles, thus reducing the measured shrinkage. In one series of mortars and concretes of equal water cement ratio, equal cement content, and uniformly-low air voids, the shrinkage was about equal for all maximum sizes up to ¼ inch. As the maximum size of aggregate was increased above ¼ inch, the shrinkage decreased rapidly, indicating internal cracking for the larger sizes. In order to cover the large range of maximum sizes of aggregate from .02 to ¾ inch the cement content was very high (mix 1:1) in this series of tests, but yet the shrinkage of concrete containing ¾ inch aggregate was only about half that for the small sizes and not much higher than for ordinary mixes of concrete. The advantage of reducing shrinkage through promotion of internal cracks may well be questioned, but it must be appreciated that the cracks are too small to be visible and the dried concrete actually offers increased resistance to freezing and thawing. The promotion of internal cracking offers the one most promising means of reducing overall shrinkage.

The effect of thickness of concrete section upon shrinkage is of utmost importance. The drying of concrete is such a slow process that even in thin sections, full shrinkage to equilibrium is seldom approached. The moisture in the interior of drying concrete drifts toward the surface as a vapor through pores that are too small to see with a microscope. The concentration or humidity of the moisture vapor increases with depth below a surface. Liquid water remains only in the smallest pores near the surface but fills larger pores also at greater depths. The liquid water in the smallest pores will never leave at ordinary humidities, but only under high vacuum or high temperature, and then very slowly. Thus the picture of drying concrete is that of a minutely porous solid, with the dampness of the air in the pores increasing with depth until, for an initially saturated concrete, it approaches 100 per cent relative humidity at the greatest depth of drying. It is the tendency for the dampness to equalize that causes the slow drift of moisture toward the dry surface, there is no other force causing moisture to leave the concrete. In fact, the humidity in surrounding air must be reduced somewhat below 100 per cent before any moisture leaves the concrete, because the water in the concrete is not pure.

Many tests have been made to show the variation in shrinkage for different sizes of concrete specimens. In most cases, however, the tests were made on blocks or cylinders drying from all faces. Consequently, the results were complicated by stresses in all directions and no simple relations were revealed. Only recently, the technique of testing specimens drying from one or two faces only was developed. Thus, a slab of concrete sealed to prevent drying on all edges, but permitted to dry from one or both faces simulated quite accurately a wall drying from one or both faces. The sealing of edges was accomplished either by using thin-copper forms, or by application of a special preparation of wax, which was applied in several coats (most of the commonly used curing compounds were found to be imperfect for this purpose). Contractions were measured at the edges, but away from the corners, on several gage lines.

The results of some of the recent tests on slabs drying only from the two faces are shown in Fig. 1. The values shown represent the average shrinkage over the thickness of the slab for several different slab thicknesses. All specimens were given a preliminary moist curing period, during which they did not shrink, and then they were stored in a controlled room at 50 per cent relative humidity and 70° F. The concrete was about average, building-grade concrete.

Fig. 2 presents another set of results on similar slabs showing the effect of humidity of the air. As might be expected, the shrinkage is greater and more rapid for the drier storage represented by lower humidity, but the difference is not as great as had been predicted. It will be pointed out later that drying at higher humidity, at least within the range from 25 to 75 per cent, has no large effect on the tendency to crack.

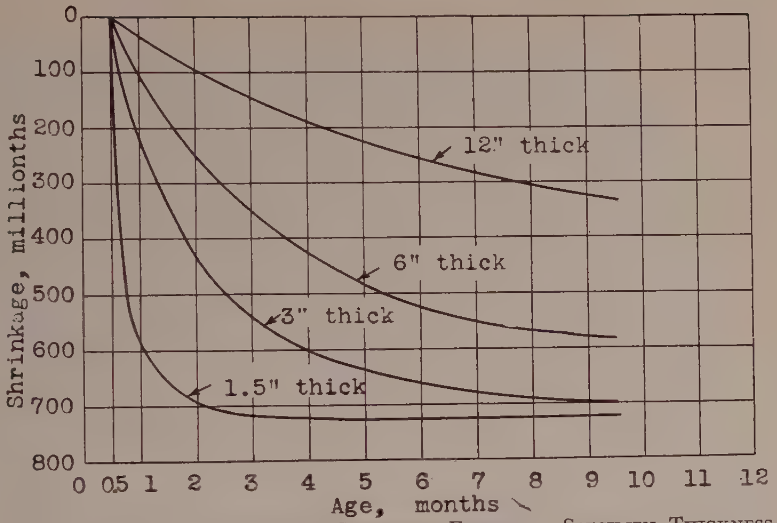

Fig. 1—Drying Shrinkage of Concrete—Effect of Specimen Thickness

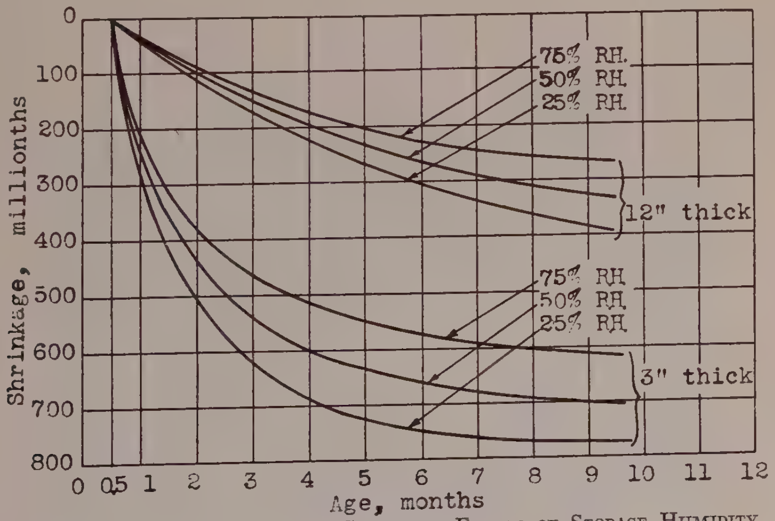

Fig. 2—Drying Shrinkage of Concrete—Effect of Storage Humidity

RESULTS OF RECENT CRACKING STUDIES

About three years ago, tests were begun in the laboratories at M. I. T. to study the tendency of concrete to crack, as contrasted with its tendency merely to shrink. It was believed then that the shrinkage of concrete as affected by most of the important factors had been investigated quite thoroughly and it seemed appropriate to go on to the more complicated problem of studying cracking, which involves strength, elasticity, and plastic flow as well.

The first type of specimen used to compare the cracking tendency of different concretes, was a column of concrete restrained by a heavy bar of steel on its centerline. The steel bar was threaded at both ends to provide maximum bond to the concrete, but was coated for about ten inches at its mid length to prevent bond there. The intention was to subject the whole specimen to drying in air after a preliminary moist curing period, so that the concrete would tend to contract against the restraint of the steel bar. Companion specimens of similar cross section but without steel rods were tested for free shrinkage, and strain was measured also on the restrained specimens to determine the stress and degree of restraint. In Fig. 3 are shown one of the column specimens, a companion specimen for free shrinkage, and a strain gage for measuring length changes.

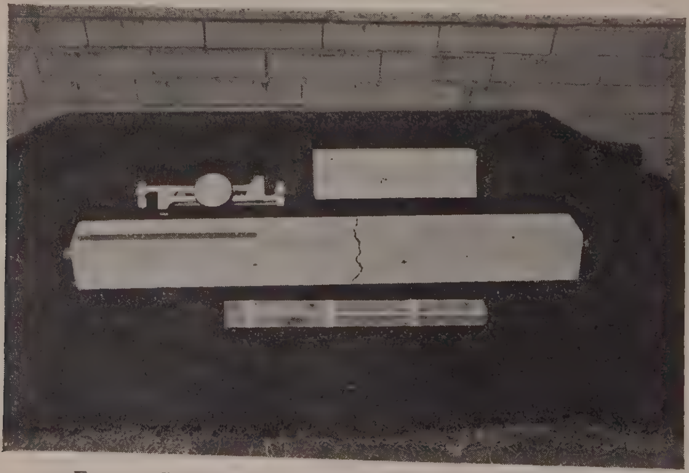

FIG. 3—COLUMN-TYPE SPECIMEN FOR CRACKING TEST
(STRAIN GAGE, FREE SHRINKAGE SPECIMEN, AND STANDARD BAR, ALSO SHOWN)

These tests gave such interesting results that a brief progress report was published in 1939. When a crack appeared in a specimen, it usually was large enough to be detected easily. Some of the results, however, did not appear logical and later tests with a new type of specimen made it necessary to reverse some of the earlier conclusions. The results were not believed to be in error for the conditions of the tests, but the conditions were not believed to be fair for most applications.

Specifically, the restrained-column type of cracking specimen had two faults. The degree of restraint provided by the steel was variable and there was an indeterminate concentration of stress at the corners of the column. The degree of restraint was unduly variable because the various concretes compressed the steel more or less depending on their effective elastic moduli. The variation would not have been too large if the degree of restraint could have been near 100 per cent in all cases, but it was found impracticable to make the restraint higher than about 50 per cent. The restraint was lower and more variable than had been expected because there appeared to be some unavoidable yielding of the concrete on the steel threads.

The concentrations of stress at the corners of the column specimens could have been avoided either by making the specimens cylindrical or by sealing opposite faces, but it was preferred to develop a new type of cracking specimen.

Therefore, a ring type of specimen was adopted, in which the concrete was cast around a ring of steel. The concrete was coated on the sides of the ring so that drying occurred only from the outer surface. Companion specimens, coated on all faces save one, were used to determine free shrinkage. These specimens curled freely, so the shrinkage as measured in the drying face was believed to be equal to the true free shrinkage of the outer concrete in the ring. This type of cracking specimen offered several advantages. First, the degree of restraint could be made high and nearly constant. Second, the problem of slip of concrete on steel was avoided. Finally, the correct strain at the outer surface could be determined, with the help of the companion specimens. This type of specimen has now been used successfully for more than a year. It is illustrated in Fig. 4.

Some of the results are worth mentioning. Thus far, all concretes which have cracked when subjected to the most severe drying

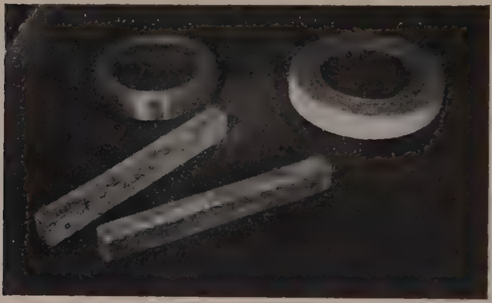

FIG. 4—RING TYPE SPECIMEN FOR CRACKING TEST
(STEEL RING ALONE AND COMPANION BARS FOR FREE SHRINKAGE ALSO SHOWN)

of 25% relative humidity have also cracked when subjected to less severe drying of 50 and 75% humidities. Although longer time was required for cracking to occur at the higher humidities, the strain required to crack the concrete was found to be progressively less at higher humidities. This result is probably due both to the lesser plastic flow at higher humidity and also to the lesser strength of damp concrete. Dry concrete has been found to exhibit a plastic flow several times greater than that of moist concrete. Also, a few tests have indicated greatly increased tensile strength for dry concrete.

Another interesting result is the surprising effect of long duration of preliminary moist curing. In one series of tests comprising three different cements, all of the restrained rings that were moist cured for 28 days before drying, cracked after a few days of drying. But no specimens cracked where the preliminary moist curing period was reduced either to 7 or to 3 days before drying. This seems remarkable in view of the greater strength of the concrete which was moist cured for the longest period, but the lesser plastic flow for the longer-cured concrete appears to account for the result. Among a great many concrete cylinders tested for drying shrinkage in the M. I. T. laboratories over a period of years, it was found that all cylinders which had been moist cured for more than 28 days before being subjected to drying, were covered with surface cracks. No cylinders which had been given shorter periods of preliminary moist curing were cracked. This seems to lend support to the results from the ring-type of cracking tests, despite the fact that the limiting duration of moist curing was not exactly the same in the two widely different cases.

The tests indicate that there is no appreciable difference in the cracking tendency of rich and lean mixes, provided the rich mixes have appropriately coarser graduations of aggregate.

A timely result, in view of the tendency toward the use of air entraining agents for highway concretes, concerns the effect of such agents on the cracking. Despite the greater free shrinkage of concretes containing several percent of air due to their content of Vinsol resin, these concretes resisted cracking progressively better as the amount of Vinsol resin was increased to 0.05%, the maximum included in the tests. A word of caution should be added in this regard, because if cracks are not entirely prevented, they open wider in accordance with the greater shrinkage and then nothing is gained. It would be far better if the cracking tendency could be reduced without increasing free shrinkage.

The character of the aggregate has a pronounced effect on the cracking. Thus far, the principal comparisons have been made between concretes containing a perfectly sound gravel and a glacial gravel not entirely sound. The glacial gravel made concrete which was far less resistant to cracking, because the particles of glacial gravel exhibited appreciable shrinkage in themselves.

Finally, the effect of curing compounds should be mentioned. There are several so-called clear curing compounds on the market that are sprayed on the surfaces soon after placing the concrete or stripping the forms, as the case may be. The best such material seems to be one made with a turpentine gum in a solvent. None of the ring-type cracking tests have been made on these materials but many other tests and observations have been made. Although the coatings do not seal the concrete perfectly, they slow down the shrinkage so greatly that plastic flow can take care of the shrinkage and give a result that cannot be obtained by long-time moist curing. In field structures, cracking has been reduced greatly by the use of curing compounds.

These results are admittedly only fragmentary as yet, but it seems that cracking tests of the type described can be used to develop a concrete which will resist cracking better under most conditions.

DESIGNING FOR THIN WALLED SECTIONS

(Presented at a meeting of the Designers Section of the Boston Society of Civil Engineers held on February 11, 1942.)

By E. J. W. Ragsdale*

I have often wondered why nobody has ever taken for a thesis the stress analysis of a bamboo fishing pole. It certainly represents Nature's finest effort toward a structural accommodation. Using a high grade material, the bamboo tree places it sparingly and to advantage. A variable bending moment is taken care of by appropriate changes of diameter and of wall thickness. Shear loads are resisted by bulkhead joints which are spaced with almost mathematical precision. Truly, there is much structural wisdom to be had from the examination of a simple bamboo pole. It serves as a guide in light weight construction, and light weight construction is sadly in need of a guide. Too new to have developed a sound literature, light weight construction lacks any indication of standardization. The individual designer has enjoyed wide latitude and has apparently made full use of it. Although the problem in itself is clearly defined—which is unusual—the approaches have been many and widely varied. Usually there is one outstanding material in every art. Its position is unchallenged. Leather, for instance, is still the material of shoemaking. We have no suitable substitute for the wooden cross-ties of a railroad. Steel remains the one metal for ships and for structures. But, when it comes to light weight construction, and more particularly in its finest development as in aircraft, we find five widely different materials, all competing for position and all strongly supported by their sponsors. First there is wood, then the lighter alloys such as magnesium and aluminum, next is high tensile stainless steel and last of all the plastics.

What can one do with such a situation? It can't be argued, for by some strange coincidence, all five of these materials balance out in their relation of weight and strength. Even the moduli of elasticity shows the same proportionality. Aluminum, for instance, is one-third as heavy as steel but, by the same token, it also is only one-third as strong. And so it goes for all of the others. Theoretically, one can build a wooden structure which would be just as light and just as strong as a well built equivalent structure of high tensile steel. The hitch comes in that expression "well built". Bulk is a great help to the designer, and wood certainly has bulk. In fact, all five of the materials mentioned differ chiefly in their bulk. Bulk translates itself into stability. Design is easy so long as general and local stability do not upset all calculations. In fact, the title of this paper might well have been reduced to one word, namely, "Stability".

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When designing for thin walled sections, stability does become a governing factor. Of what use can a material be, although it may have a tensile strength of even 200,000 pounds per square inch, if it evades the load instead of taking it? The spokes of a bicycle wheel are possibly the only structural members which carry a heavy load and without evasion. Rarely does one find pure tension outside of text books. Tension, or even compression, is usually contaminated with shear or some other condition. When I went to school we used to figure pin-jointed structures, largely because they were the only ones which we could figure. If the damned thing got into redundancy we were sunk. Now redundancy holds no terrors and is, in fact, invited. A redundant structure is far more efficient, actually, than would be a pin-jointed one, and with the Theory of Least Work—which means more work than I care to think of—it can be figured to a nicety. The side frame of a railroad passenger car may evolve—and does—some 47 simultaneous equations, but what loss are a few equations when much material is saved both in the building and in the subsequent hauling around. A little of the brain can actually save a lot of the brawn.

But, as you will note, I wander from my theme. One is apt to. Stability does invite evasion even in discussion. To get back to the five materials of light weight construction, wood suffers little or no instability. A panel of spruce, for instance, has a stability factor of some 22 times that of an equivalent panel of aluminum, in size and weight. Again, the aluminum panel is 9 times more stable than would be one of steel. So accordingly, wood is almost 200 times more stable than steel and, by the same token, about that much easier in design. Bulk is a great help to the designer. Thinness, on the other hand, is a problem. It permits the introduction of so many factors which are extraneous to what should be the main issue. Of what use is the

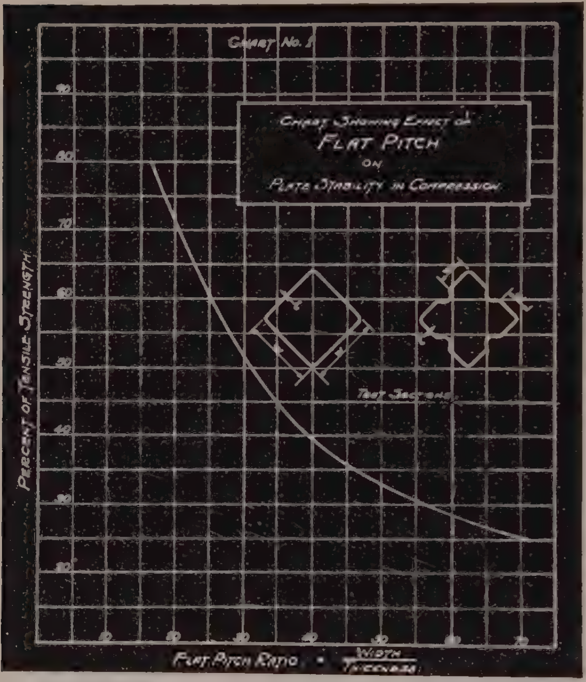

Fig. 1.—Effect of Flat Pitch on Plate Stability in Compression

basic formula f = My/I if some part of the material goes haywire long before the resultant fibre stress has been attained? By going haywire I mean buckling. A buckle represents an effort to avoid some one stress and in doing so introduces possibly a much higher stress locally as well as in the adjacent material. It is axiomatic that thin steel will buckle, so the answer is to buckle it to begin with. Only it has to be buckled right and in the proper direction. A corrugated sheet of iron is a classic example of pre-buckling. When that is attached to a flat plate a remarkably stiff panel results. As has been said before, an aluminum panel is inherently 9 times stiffer than an equivalent panel of steel. By using the corrugated-flat plate combination, however, the steel panel can become 10 times stiffer than the aluminum sheet. The only problem is how to assemble the panel cheaply and how to proportion the corrugations so as to develop the full properties of the steel. Automatic welding answers the first part, while the second has now been reduced to formula. That concerns itself with what we know as "flat pitch". Flat pitch is the relation between the unsupported width of a face or of the flange of a section and the metal thickness. For instance, if a 2″ square tube has a wall thickness of .05″ the flat pitch ratio is .05″ into 2″ which is 40. By experiment we have established a flat pitch curve. With this we can go in at any given flat pitch and determine the percentage of tensile strength at which a short column will fail in compression. We are interested in short columns because there is no use in figuring with long column formulas so long as thin wall thicknesses may invite failure by buckling long before the formula says it should fail. (See Fig. 1).

Much similar work has been done for round tubes, but round sections, like the bamboo pole, have their limitations of assembly. Squared sections make for much easier attachment, especially through the use of gusset plates.

Of course, the flat pitch curve has to be used with some discretion. An outstanding flange will naturally buckle before a flat face which is stiffened by a bend at each edge. The curve is based upon the latter condition. With interpretation it is also applicable to flat plates such as gussets.

Some short columns have been known to develop in compression the full tensile strength of the metal, namely, 150,000 pounds per square inch. This is unusual, of course, but compressive values of 100,000 pounds per square inch are quite usual. In this case, as can be seen from the curve, the flat pitch ratio is 22. An illustration shows two sections of a center sill for a railroad car. The more slender one has a cross-sectional area of 12.6 square inches and has sustained in compression a loading of 1,430,000 pounds, or 116,000 pounds per square inch. The other has been reinforced to give 18 square inches of area. It could not be failed at 2,000,000 pounds, which is the capacity of the Budd testing machine. At that load, the fibre stress figures at 111,000 pounds per square inch. This basic section is not only an efficient one, but one which also offers every facility for the attachment of correlated structures or of incidental equipment.

The flat pitch ratio of the smaller section varies from 18 to 21.6. Considering it, element by element, the flat pitch curve indicates a total compression strength of 1,394,700 pounds. This is within 2% of the ultimate strength as established by test.

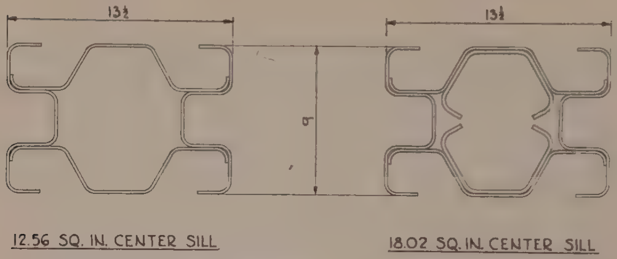

FIG. 2—CROSS SECTIONS OF CAR CENTER SILLS

Of course, this section would not be nearly so efficient as a long column, but when used as a center sill of a car, it is stabilized by floor beams every two feet or so. Actually the sill develops the same strength in the car that it does when tested as a five foot test specimen.

The point I wish to establish is that thin metal can be so shaped that it will actually sustain loadings up to, or even beyond, the yield point. When that yield point is 110,000 pounds per square inch the problem is considerably more involved than it is with ordinary structural shapes of mild steel whose yield point is only some 33,000 pounds per square inch. Another incidental point is that by roll-forming of long coils of strip steel, the scrap loss is cut to a minimum. The number of required sections can also be reduced. In our railroad work, for instance, we use not more than 27 sections. Some of these are assembled back-to-back or into a cluster as in the center sill, but actually only 27 sections need be rolled. Against this I note that the steel book lists 367 special car-building sections in addition to the other 650 standard structural shapes offered. These come in standard lengths and the scrap may run as high as 20%. Stainless steel sections are rolled from long coils, some a thousand feet in length, and are cut exactly to required length. The draw-rolling constitutes an interesting chapter in itself, but one which does not properly belong here. Suffice it to say that the roll forming must not add to the cold working of the metal. The coils have already been cold rolled to exact physicals. Any additional cold working might upset the balance between tensile strength and ductility.

So far, I have indicated only the easy part of designing for thin walled sections. That concerns the capacity of a section to take compression. I have neglected to mention how to put those sections together and to speak of the ever present question of failure by fatigue. I am sorry to have to bring up either of these questions. Both are important and neither can be reduced to generalities.

To go back to my genesis, the trouble with bamboo is that nobody but a Chinaman can put it together. Otherwise it is a perfectly good section. It simply doesn't fit into a composite structural picture. It does very well as a fishing pole, but has had a short life as the answer to aircraft requirement. Yes! It was tried. So was steel tubing. A simple joint of tubing took some twenty minutes to gas weld and required quite some skill. It never was a production job. On the other hand, a simple and very efficient joint of stainless steel

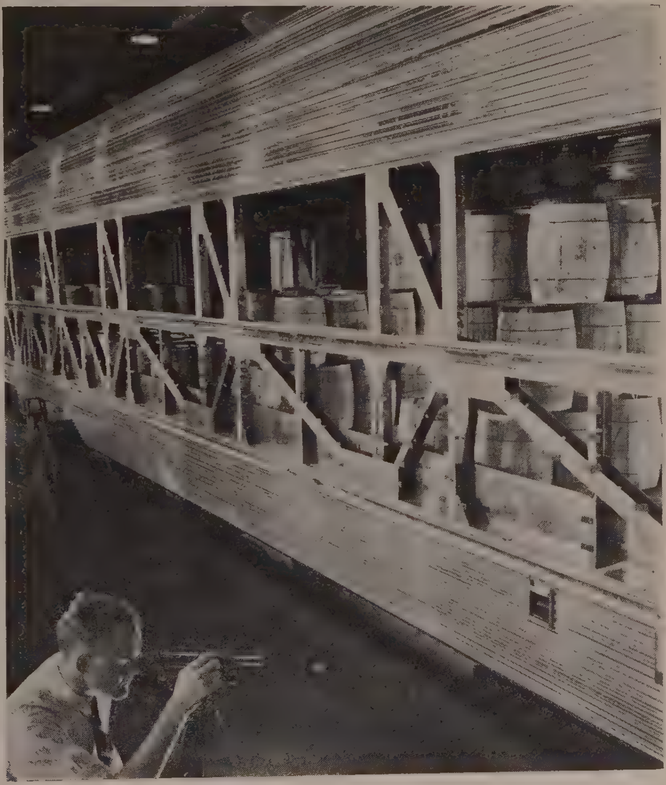

FIG. 3—VERTICAL LOAD TESTS OF A CAR STRUCTURE

sections can be made in three minutes and with unskilled labor. Most of the connections used will develop the full strength of the weakest member entering into them. This is partly due to the effectiveness of the SHOTWELD and partly to design. In stainless steel the weld develops about twice the shear strength of a rivet of like diameter and welds can be placed ever so much closer together than can rivets. Furthermore there is no hole to reckon with. A 90% efficient single lap joint is common practice. Joint design is fairly simple in principle. It involves sufficient gusset area to permit the required weld pattern and the avoidance of eccentricity. This means twin gussets—one on each side of the member. The size of the gussets reflects the high loading expected of the structural members. It also introduces a redundancy which is difficult to figure. But figures are meaningless if the gusset buckles or weaves. The position of the compression member in the joint usually determines this. The tendency is easily recognized and can be corrected by flanging over the gusset edges or by introducing a bead.

It is all a terrible combination of tin smithing and mathematical gymnastics. Sometimes one trusts to eye-evaluations and at other times solace can be found in equations. I personally am geometric-minded. I have to see things. Dr. Eksergian, who does our equation stuff, is algebraic minded. I have really never understood how he arrives at an answer. All I know is that he has to work harder than I do and uses up more paper. It's strange how often our different approaches eventually arrive at the same destination. The Budd management, however, may have suspicioned this agreement, for it built a quarter of a million dollar test plant. In this a complete railroad car is tested under almost every conceivable condition of loading. The Doctor's figures are strangely correct. Strain gauges attest this.

Incidentally, it may be of interest to know that after a hundred years of car building, the Budd Company was the first to recognize that a car structure could be accurately calculated and that the Budd Company was the first ever to erect a test plant for complete stress investigation of a whole car. Previously car building just grew up. Its text book was the history of failures in service or in accident. As a result, passenger cars soon commenced to weigh 165,000 pounds. One thing, however, could be said in their favor. They were safe. No more safe, however, than the modern stainless steel car weighing some

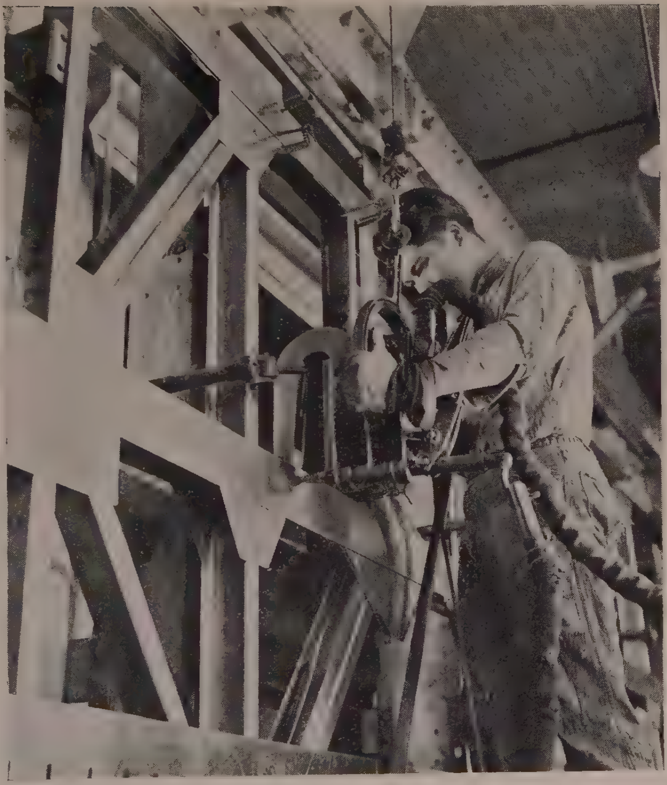

FIG. 4—SIDE FRAME ASSEMBLY BY MEANS OF SHOTWELD SYSTEM

60,000 pounds less. Weight begets weight and often defeats its own purpose. It makes for "rigidity". Only lately has it become apparent that "resiliency" spells greater safety in accidents of impact than does rigidity.

When you are dealing with thinness, the technic changes. Formerly the side strength of a railroad car rested largely in a plate girder extending from the floor to the window ledge. The plate was one-eighth inch thick. It was fairly stable. Had it been .030 inch instead, it would have broken into a tension field and would have looked uninspiring. When organized, however, into a deep truss system, the .030 inch metal becomes even more effective than the one-eighth inch stuff below the window. But windows have to be reckoned with and the result is a Vierendeel truss instead of the simpler and more efficient Pratt truss. Some day I am going to have the courage to introduce triangular windows. Then I will use the Pratt truss. So far, it is confined to freight cars, those with wooden side sheathing.

The .020 inch roof sheets also enter into the structural picture. After all, the roof is the biggest structural element of the whole car. It ought to go to work. And it does. The roof, being corrugated so as to withstand 137,000 pounds per square inch in compression specimens, actually takes care of one-third of the total bending moment.

So, as said before, when you design for thin stuff you know it will wrinkle anyhow. Therefore, do the wrinkling yourself before the stresses have a chance. Do a bit of tin-smithing and then let the Doctor figure out how near right you are. Settle the argument in the test plant, and then hope that fatigue doesn't set in.

Fatigue failure is the bugaboo of all design, thin walled or otherwise. And, I say "design" advisedly, for fatigue failure results not so much from lack of fatigue resistance of the metal as it does from fatigue exposure. Actually stainless steel has the highest fatigue resistance of any known structural material. The laboratory tells us that it is 79,000 pounds per square inch, about half of its tensile strength. That is three or four times greater than any normal stressing, and normal stressing is very rarely reversible. So fatigue failure need not be feared where it usually is feared. It usually starts in some innocuous little corner which merits nothing but mathematical contempt. A pained aftermath finally establishes that there has been a fatigue exposure of some few hundred percent above the known fatigue resistance of the metal.

As a result of many years' association with thin walled design, I have arrived at two axioms, both of which sound like Irishisms.

1. Fatigue failures usually occur in areas of no stress.

They come from oil-canning.

2. No hole ever failed by fatigue.

The second is really a corollary of the first. If any metal isn't doing its stuff, cut it out and flange the hole. Idleness is just as bad in a structure as it is in society. It is heading for trouble and usually finds it. Fatigue failures are not confined to metals. You will find quite a few among the neighborhood boys. And fatigue doesn't come from overwork, it comes from not being used to work.

Most of us are better engineers than we are fathers. I know exactly where to suspect fatigue in a structure and how to correct it. But, I don't know how to put a hole in the boy or how to crimp his style.

OF GENERAL INTEREST

PRIZES AWARDED AT ANNUAL MEETING ON MARCH 18, 1942

The Desmond FitzGerald Medal

TO HOWARD M. TURNER AND ALLEN J. BURDOIN, MEMBERS

Presentation made by President Albert Haertlein

Mr. Richard S. Holmgren, Chairman of the Committee on Award of the Desmond FitzGerald, consisting of Richard S. Holmgren, Miles N. Clair and Donald W. Taylor, outlined the purpose of this prize which was instituted and endowed in 1910 by the late Desmond FitzGerald, a past President and Honorary Member of this Society, and is awarded annually for a paper presented by a member and published during the year which is adjudged worthy of special commendation for its merit.

The paper selected by this committee and recommended to the Board of Government for the award was that by Howard M. Turner and Allen J. Burdoin, Members, entitled "The Flood Hydrograph" presented at a meeting of the Hydraulics Section held on May 7, 1941 and published in the July, 1941, JOURNAL.

President Haertlein on behalf of the Board of Government presented the Desmond FitzGerald medals to Mr. Turner and Mr. Burdoin, who accepted them with appropriate remarks.

The Designers Section Prize

TO EDWIN B. COBB AND CHESTER J. GINDER, MEMBERS

Presentation made by President Albert Haertlein

Mr. Miles N. Clair, Chairman of the Designers Section Prize Award Committee, consisting of Miles N. Clair, Anthony S. Coombs and Kimball R. Garland, outlined the purpose of the Designers Section Prize which was authorized by the Board of Government in 1924 to be given for a worthy paper given in the Section by a member of the Section.

The paper selected was entitled "Design of Fabricated Plate Steel Tees, Laterals and Wyes of Large Diameters for the Pressure Aqueduct of the Boston Metropolitan District Water Supply Commission," by Edwin B. Cobb and Chester J. Ginder, Members, presented at a meeting of the Designers Section held on November 14, 1940, and published in the April, 1941, JOURNAL.

The prize consisted of books: "Handbook of Hydraulics," by Horace W. King, "Handbook of Engineering Fundamentals," by Ovid W. Eshbach, "Sewage Treatment," by Karl Irmhoff and Gordon M. Fair, "Strength of Materials," by S. Timoshonko, "Hydraulics of Steady Flow in Open Channels," by Sherman M. Woodward and Chesley J. Posey. Mr. Cobb and Mr. Ginder accepted this prize with fitting remarks and expressed their appreciation of the prize.

The Northeastern University Section Prize

To WARREN T. BOUTELLE, STUDENT MEMBER

Presentation made by President Albert Haertlein

Mr. Richard S. Holmgren, Chairman of the Committee on Award of the Northeastern University Section Prize, consisting of Richard S. Holmgren, Miles N. Clair and Donald W. Taylor, outlined the purpose of this prize, which was authorized in 1931, for a worthy paper by a student member.

The paper selected was that by Warren T. Boutelle, Student Member, and entitled "Sewage Treatment at Camp Edwards," presented at a meeting of students at the University held on May 21, 1941. The prize consisted of books: "Waterworks Handbook of Design, Construction and Operation," by Alfred D. Flinn, Robert Spurr Weston and Clinton L. Bogert, "Handbook of Hydraulics," by Horace W. King, and "Concrete Engineers Handbook," by George A. Hool, Nathan C. Johnson and S. C. Hollister. Mr. Boutelle accepted the prize and expressed his appreciation of being selected as the recipient of this prize.

NEWLY ELECTED HONORARY MEMBERS

Boston Society of Civil Engineers

Honorary Membership in the Boston Society of Civil Engineers was conferred on the following members at the Annual Meeting of the Society held on March 18, 1942. Following the Annual Dinner, President Albert Haertlein presented each of the three new Honorary Members a certificate of Honorary Membership, framed in a morocco leather case.

PROF. CHARLES METCALF ALLEN, Professor of Hydraulic Engineering, Worcester Polytechnic Institute, Worcester, Mass., who has been a member of the Society since April 19, 1911 and was President 1926 to 1927. The certificate of Honorary Membership read as follows:

"In recognition of his service as a teacher and an experimenter, who blended the old art of hydraulics with the new science of fluid mechanics and seasoned them with the salt of common sense."

ARTHUR WARREN DEAN, Consulting Engineer, formerly Chief Engineer of the Massachusetts Highway Commission, of the Massachusetts Department of Public Works and of the Massachusetts State Planning Board, who has been a member of the Society since December 18, 1895 and was President of the Society in 1933 to 1934.

The certificate of Honorary Membership read as follows:

"In recognition of his service in introducing the principal of Engineering design into the construction of the highways of Massachusetts."

COL. CHARLES RICE GOW, President of Warren Brothers Corp., who has been a member since March 18, 1903 and was President of the Society, 1915 to 1916.

The certificate of Honorary Membership read as follows:

"In recognition of his rare knowledge of men, materials and the deep seated forces of nature and of his service to Government and Industry."

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETING

Boston Society of Civil Engineers

JANUARY 14, 1942.—A regular meeting of the Boston Society of Civil Engineers was held this evening at the Engineers Club and was called to order by President Haertlein. This was a Joint Meeting with the Designers Section, B. S. C. E. Fifty-eight persons attended the meeting and fifty-four attended the supper.

President Haertlein announced the death of the following member:

Robert S. Hale, who was elected a member on December 20, 1893, and who died December 31, 1941.

President Haertlein stated that there is a vacancy in the office of Treasurer, due to the resignation of Charles L. Coburn, who has accepted an appointment at the Quonset Naval Air Station, Quonset, Rhode Island. A report was presented from Prof. John B. Babcock, Chairman of the Nominating Committee, presenting the nomination of Chester J. Ginder, for Treasurer, to fill the unexpired term of Mr. Coburn.

On motions duly made and seconded, it was voted that the report of the Nominating Committee be accepted.

Voted that the nominations be closed and that the Secretary be instructed to cast one ballot for the nominee, Chester J. Ginder.

The Secretary thereupon cast the ballot and President Haertlein announced the election of Mr. Ginder as Treasurer.

The President called upon Prof. John B. Wilbur, Chairman of the Designers Section, who stated that the only business to be conducted by that Section was the election of a nominating Committee for that Section.

President Haertlein then introduced the speaker of the evening, Mr. Roy W. Carlson, Associate Professor of Civil Engineering at Massachusetts Institute of Technology, who gave an interesting talk on "Cracks in Concrete".

The speaker was given a rising vote of thanks.

Meeting adjourned at 8:50 P. M.

EVERETT N. HUTCHINS, *Secretary*

FEBRUARY 18, 1942.—A regular meeting of the Boston Society of Civil Engineers was held this evening at the Engineers Club and was called to order by the President, Albert Haertlein at 7:15 P. M. Seventy-two members and guests attended this meeting, and 59 persons attended the dinner.

The President announced the deaths of the following members:

William J. Backes, who was elected a member February 20, 1929, and who died January 20, 1942.

Austin B. Mason, who was elected a member February 19, 1936 and who died February 5, 1942.

The Secretary reported on the election of new members on this date, as follows:

Grade of Member: Francis J. Alves, Carl H. Crawford, Edward C. Drake, Ralph E. Fadum, Frederick S. Gibbs, *Robert J. Greer, Frederick E. Griffin, *Kenneth F. Knowlton, *William S. Mariner, Charles G. McDonald, Robert W. Moir, *John S. Ross, James C. M. Tillinghast, Arpad A. Warlam, *Alan K. Willard, Paul A. Wirth.

Grade of Student: †Penneth M. Cline, Donald J. Fogarty, †Henry G. Seeley.

The President stated that this is a Joint Meeting with the Hydraulics Section, B. S. C. E., and consequently called upon Mr. Stanley M. Dore, Chairman of that Section to conduct any necessary business to be completed at this time.

The President introduced the speaker, Mr. William Glenn Hoyt, Principal Hydraulic Engineer, U. S. Geological Survey, Department of the Interior, Washington, D. C., who gave a paper, "A discussion of the 1940 Flood Report of the Boston Society of Civil Engineers."

Following this paper a number of members discussed the Flood Committee Report and the paper presented by Mr. Hoyt, including Messrs. H. M. Turner, S. S. Kent, H. B. Kinnison and others.

The meeting adjourned at 9 P. M.

EVERETT N. HUTCHINS, *Secretary*

MARCH 18, 1942.—The ninety-fourth annual meeting of the Boston Society of Civil Engineers was held today at the Boston Chamber of Commerce and was called to order at 4:30 P. M. by the President, Albert Haertlein.

President Haertlein announced the deaths of the following members:

Henry A. Varney, who had been a member since March 18, 1896, and who died April 10, 1941.

Charles A. French, who had been a member since June 10, 1914, and who died April 6, 1941.

The minutes of all previous meetings of the year from the meeting of February 19, 1941 to December 17, 1941, inclusive, which have been printed in the various issues of the Journal were approved as printed.

The Secretary reported the election of the following members on this date:

Grade of Student: Allen W. Abbott, Peter Andrews, Richard Biggs, Henry J. Bishop, Charles W. Blanchard, Walter Bodnar, David Bornstein, Richard M. Burbank, Joseph Capone, Jr., Paul A. Caputo, Jr., Patrick J. Cosgrove, Robert J. Coughlin, Edward M. Cummings, Bradford Graves, John F. Heaney, Harry C. Hunt, John W. Ireland, Wilder E. Kelle, Jr., Esa M. Khoury, Robert N. Kuehn, Edward R. Lamb, Joseph C. Lawler, James R. Lowell, Jr., Alan Levy, James G. Makrys, Murray Marks, Peter A. Moldauer, Richard W. Newcomb, Carl R. Paladino, Samuel J. Pattison, Jr., Walter I. Piper, Charles L. Pistorino, Lee E. Pray, Leon E. Rasanen, Viljo W. Rekola, Elmer E. Smith, Richard E. Sprague, Roderick Van Tuyl, Robert S. Wharton, Gordon G. Woods.

The Annual Reports of the Board of Government, Treasurer, Secretary and

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*Transferred from grade of Junior.
†Transferred from grade of Student.

Auditors were presented. Reports were also made by the following committees: Membership, Social Activities, Relations of Sections to Main Society, Welfare, Library, Subsoils of Boston and John R. Freeman Fund Committee.

Voted that the reports be accepted with thanks and placed on file, and that they be printed in the April, 1942, JOURNAL.

With reference to the report of the Society's Committee on Floods, Mr. Howard M. Turner, Chairman, stated that during this year the report had been put in final form for publication and printed in the January, 1942, JOURNAL, and that the Committee's work was completed.

Voted that the Society express its appreciation to the Committee on Floods for its comprehensive and excellent report.

Voted that the incoming Board of Government be authorized to appoint such Committees as it deems desirable.

The report of the Tellers of Election, Frank L. Flood and Kimball R. Garland, was presented and in accordance therewith the President declared the following had been elected officers for the ensuing year.

President—Charles R. Main

Vice-President—Howard M. Turner (for two years)

Secretary—Everett N. Hutchins (for one year)

Treasurer—Chester J. Ginder (for one year)

Directors—Stanley M. Dore and Herman G. Dresser (for two years)

Nominating Committee—Charles O. Baird, Francis H. Kingsbury, Frederic N. Weaver (for two years)

The retiring President, Albert Haertlein, then gave his address on, "The Effect of Blast on Buildings".

Forty-eight members attended this part of the meeting.

The meeting adjourned to assemble at 7:30 P. M., the Annual Dinner being held during the interim.

The President then called the meeting to order, for the presentation of prizes.

The President requested Mr. Richard S. Holmgren, Chairman of the Committee on the Award of the Desmond FitzGerald Medal to outline the purpose of this prize and to present the candidates for this prize. The President on behalf of the Society then made the presentation of the Desmond Fitz Gerald Medals to Mr. Howard M. Turner, Member, and to Allen J. Burdoin, Member, for their paper on "The Flood Hydrograph", presented at a meeting of the Hydraulics Section held on May 7, 1941, and published in the July, 1941, JOURNAL of the Society.

The President requested Mr. Miles N. Clair, Chairman of the Designers Section Prize Award to define the purpose of the Designers Section Prize and to present the candidates for this prize. The President, on behalf of the Society, then made the presentation of the Designers Section prize, consisting of books, to Chester J. Ginder, Member, and Edwin B. Cobb, Member, for their paper on "Design of Fabricated Plate Tees, Laterals and Wyes of Large Diameters for the Pressure Aqueduct of the Boston Metropolitan Water Supply Commission", presented at a meeting of the Designers Section held on November 13, 1940, and published in the April, 1941, JOURNAL of the Society.

The President requested Mr. Richard S. Holmgren to define the purpose of the Northeastern University Section prize and to present the candidate for this prize. President Haertlein then, on behalf of the Society, presented this prize to Warren T. Boutelle, for his paper on "Sewage Treatment at Camp Edwards", presented at a meeting of students at the University held on May 21, 1941.

New Honorary Members

President Haertlein then announced that Honorary Membership in the Society had been conferred on three of the Society's distinguished members, in accordance with the vote of the Board of Government on January 14, 1942, as follows: Charles Metcalf Allen, who had been a member since April 19, 1911; Arthur Warren Dean, who had been a member since December 18, 1895; and Charles Rice Gow, who had been a member since March 18, 1903. The newly elected honorary members were presented by the President with certificates of membership.

The certificates presented read as follows:

Boston Society of Civil Engineers

In recognition of his service as a teacher and an experimenter, who blended the old art of hydraulics with the new science of fluid mechanics and seasoned them with the salt of common sense,

CHARLES METCALF ALLEN
has been duly elected an
HONORARY MEMBER
By direction of the Board of
Government
January 14, 1942

Everett N. Hutchins
Secretary
(Seal)
Albert Haertlein
President

Boston Society of Civil Engineers

In recognition of his service in introducing the principles of engineering design into the construction of the highways of Massachusetts,

ARTHUR WARREN DEAN
has been duly elected an
HONORARY MEMBER
By direction of the Board of
Government
January 14, 1942

Everett N. Hutchins
Secretary
(Seal)
Albert Haertlein
President

Boston Society of Civil Engineers

In recognition of his rare knowledge of men, materials, and the deep seated forces of nature and of his service to Government and Industry,

CHARLES RICE GOW
has been duly elected an
HONORARY MEMBER
By direction of the Board of
Government
January 14, 1942

Everett N. Hutchins
Secretary
(Seal)
Albert Haertlein
President

President Haertlein stated that it is customary to introduce the newly elected President at this time, but Mr. Charles R. Main, the new President, is sojourning in Florida, and he expects to return for the beginning of the new year's activities next month. A telegram of greetings received during the evening from Mr. Main was read by the President.

President Haertlein then introduced the guest speakers, Dr. Gerald F. Houser, Assistant Director, Massachusetts General Hospital, who gave an especially interesting talk on "An American Hospital for Communicable Diseases in England"; and Prof. John B. Wilbur, Associate Professor, Massachusetts Institute of Technology, who gave a very interesting talk on "The Smith-Putnam Wind Turbine". The talk on the Wind Turbine was illustrated with lantern slides and by motion pictures prepared by Mr. S. D. Dornbrier of the S. Morgan Smith Company which designed and erected this turbine.

One hundred forty-three members and guests attended the dinner.

The meeting adjourned at 10:15 P. M.

Everett N. Hutchins, *Secretary*

SANITARY SECTION

DECEMBER 17, 1941.—This evening the Sanitary Section held a Joint Meeting with the Main Society. The speaker was Mr. Roger W. Armstrong, Deputy Chief Engineer, Board of Water Supply of New York City, whose subject was "Delaware Water Supply System".

Further details of this joint meeting are given in the report of the Secretary of the Society, as published in the JOURNAL for January, 1942.

WALTER E. MERRILL, *Clerk*.

JANUARY 7, 1942.—A regular meeting of the Sanitary Section was held this evening at the Society rooms, attended by 43 members and guests, preceded by a supper at Patten's Restaurant, attended by 30 persons.

The meeting was called to order at 7:15 P. M. by the Chairman, George W. Coffin.

The Chairman introduced the speaker of the evening, Dr. Gail P. Edwards, Principal Sanitary Chemist, New York Department of Public Works. Dr. Edwards' subject was "The Operation of the Wards Island Sewage Treatment Plant." He described the plant in detail and showed a number of slides relative to the various plant processes and analyses. The paper was followed by a discussion, which was participated in by a considerable number of the audience. The meeting adjourned at 9:20 P. M. after giving Dr. Edwards a vote of thanks for providing a very enjoyable evening.

WALTER E. MERRILL, *Clerk*

MARCH 4, 1942.—A regular meeting of the Sanitary Section was held this evening in Richards Hall at Northeastern University, attended by 54 members and guests. Preceding the meeting supper was served to 41 persons at Childs Old France Restaurant.

The meeting was called to order at 7:20 P.M. by the Chairman, George W. Coffin.

The clerk read the report of the Executive Committee which was accepted and placed on file.

Mr. Frank L. Flood, Chairman of the "Committee on Minimum Velocity in Sewers", stated that the committee had completed its study and the report was ready for presentation. It was voted that the report of this committee be laid on the table and presented at the next meeting of the section.

Mr. Samuel M. Ellsworth of the Nominating Committee read the report of the committee, and it was voted that the Clerk be authorized to cast one ballot for the nominees as read. The following officers were duly elected to serve for the year 1942-43:

Chairman—Charles O. Baird, Jr.
Vice-Chairman—Walter E. Merrill
Clerk—Edwin B. Cobb
Executive Committee—George W. Coffin, Frank L. Heaney, William L. Hyland

The Chairman introduced the speaker of the evening, Lieut Col. Arthur D. Weston, Chief Engineer, Mass. Department of Public Health, whose topic was "The Sanitary Engineer in the Massachusetts Defense Program". Colonel Weston, who is also chairman of the Joint Committee on Health and of Planning, on Sanitation, of the Mass. Committee on Public Safety, gave a very enlightening talk on the three defense programs now under way in this State. These are being carried on as follows: (a) The State Emergency Plan; (b) Office of Civilian Defense; (c) Mass. Committee on Public Safety.

Colonel Weston's talk was illustrated with slides showing details of the various defense set-ups. Mr. E. Sherman Chase discussed the duties of the consulting engineer in the State Emergency Plan, which he said he had favored since the Louisville flood of 1937. He outlined the help to be furnished by the consulting engineer as use of laboratory facilities, installation of emergency disinfection equipment, and aid in evacuation.

Following discussion and a rising vote of thanks to the speakers for a most instructive presentation of the subject matter, the meeting adjourned at 9:15 P.M.

Walter E. Merrill, *Clerk.*

DESIGNERS SECTION

January 14, 1942.—A joint meeting of the Designers Section with the Boston Society of Civil Engineers, preceded by a dinner, was held this evening at the Engineers' Club. President Albert Haertlein presided, and called the meeting to order at 7:05 P. M.

After transaction of business by the Parent Society, John B. Wilbur, Chairman of the Designers' Section, was authorized to, and did, appoint a Nominating Committee to prepare a slate of officers in preparation for the annual meeting. The members of this committee, composed of the three most recent chairmen of the section, are: Kimball R. Garland, Chairman, J. Donold Mitsch, and Anthony S. Coombs.

Professor Haertlein then introduced Roy W. Carlson, Associate Professor of Civil Engineering at M. I. T. who spoke on the subject of "Cracks in Concrete." Professor Carlson's paper was presented in the nature of a "progress report" for data obtained to date from the investigations being carried on at M. I. T. for the past five years relative to this important subject. Shrinkage and cracking were discussed as affected by water-cement ratio, size and soundness of aggregate, void ratio, cement factor, curing, admixtures, etc. A great deal of work is yet to be done before final conclusions may be drawn and utilized in remedying concrete troubles.

A rather technical discussion followed the talk, and then after an expression of thanks to the speaker, the meeting adjourned at 8:15 P. M. Dinner attendance, 54; meeting attendance, 58.

Herman G. Protze, *Clerk.*

February 11, 1942.—A joint meeting of the Designers Section with the Highway Section, was held this evening in the Society's Rooms. Chairman John B. Wilbur called the meeting to order at 7:00 P. M.

The Clerk's reports for the previous two meetings were accepted as read. For the information of the members present, Dr. Wilbur read the advance report of the Nominating Committee presenting a proposed slate of officers for the coming year as follows: Chairman, Emil A. Gramstorff; Vice Chairman, Herman G. Protze; Clerk, Lawrence M. Gentleman; Members of the Executive Committee, Burtis S. Brown, Murray H. Mellish, Eugene Mirabelli. Although the report was accepted as read, nominations remain open until the next meeting, at which time election of officers will take place.

Following this business session, the Chairman introduced Col. E. J. W. Ragsdale, Chief Engineer of the Edw. G. Budd Manufacturing Company, Philadelphia, who spoke on the subject of "Structural Designing for Thin Wallled Sections." Col. Ragsdale's illustrated paper described in a jocularly clear manner the problem of designing and constructing railroad cars and side-frames, employing different materials and various types of sections. The effect of bulk, stability, resiliency, rigidity and fatigue upon light-weight structures was clearly indicated. Methods of fabrication, automatic shot welding, and laboratory testing of full sized units were also discussed.

Col. Ragsdale gave one of the most interesting and "meaty" talks of the year and he has been invited to present his paper for publication in the Journal of the Society. After an interesting discussion, the meeting adjourned at 8:20 P. M. Attendance 27.

Herman G. Protze, *Clerk*

March 11, 1942.—The annual meeting of the Designers' Section was held this evening in the Society's rooms. Chairman John B. Wilbur called the meeting to order at 7:00 P.M.

The clerk's report of the last meeting was accepted as read. For the information of the members present the report of the Executive Committee on the Section's activities for the year was presented by the clerk. The Nominating Committee, composed of the three recent past chairmen of the Section submitted its report through Mr. Kimball R. Garland, Chairman of that committee. The report was accepted, and, no nominations being made from the floor, the following officers were elected for the ensuing year: Chairman, Emil A. Gramstorff; Vice-Chairman, Herman G. Protze; Clerk, Lawrence M. Gentleman; Members of the Executive Committee, Burtis S. Brown, Murray H. Mellish, Eugene Mirabelli. An announcement was then made relative to the Annual Meeting of the B.S.C.E. to be held March 18, 1942.

Following this business session, the chairman introduced the speaker of the evening, Lieutenant A. C. Husband, C.E.C., U. S. Navy, Resident Officer in Charge, Navy Dry Dock, South Boston, Mass. Lieutenant Husband spoke on "Navy Building Design at South Boston" and discussed first the background of the Civil Engineering Corps in constructing shore facilities during peacetime and wartime. Priorities and the difficulty of obtaining constructive materials were also dealt with. The greater part of the evening was spent in considering the various types of foundation and building construction being employed at the Dry Dock and their relative costs and engineering feasibility.

An interesting discussion period followed Lieutenant Husband's able presentation. The meeting was adjourned at 8:15 P.M. Attendance 40.

Lawrence M. Gentleman, *Clerk.*

HIGHWAY SECTION

March 18, 1942.—The Annual Meeting of the Highway Section, Boston Society of Civil Engineers, was held today and was called to order at 5 P.M., by the Chairman, Herman S. Swartz.

The report of the nominating Committee for officers for the coming year was presented by Prof. John B. Wilbur, Chairman.

No other nominations were presented. Upon motion duly made and seconded, *Voted* that the report of the nominating committee be accepted, and that the acting clerk be instructed to cast one ballot for the candidates nominated.

The Chairman then declared the following elected as officers of the Highway Section for the coming year.

Chairman—Edgar F. Copell
Vice-Chairman—Prof. Charles O. Baird, Jr.
Executive Committee—Herman S. Swartz, William C. Paxton, Jr., Henry Chisholm
Clerk—Clinton C. Barker

The matter of changing the name of the section to Transportation Section was discussed and favored by the majority in attendance.

Louis Smith, *Acting Clerk.*

HYDRAULICS SECTION

November 18, 1941.—A meeting of the Hydraulics Section was held at 7:00 P.M. in the Society Rooms. Twenty-one members and guests were present at dinner at the Ambassador Restaurant, preceding the meeting.

The Chairman, Stanley M. Dore, conducted a brief business meeting after which he introduced the speaker, Karl R. Kennison, who spoke on "The Hydraulics of the New Pressure Aqueduct of the Metropolitan Water District".

Mr. Kennison gave an extremely interesting account of this large engineering undertaking which is under his supervision. In scope the talk covered the present construction and future possibilities, indicating the careful planning and foresight that has entered into the work. Worthy of particular note was a series of aerial photographs illustrative of the extent of the project.

After a discussion of the paper, the meeting adjourned at 9:30. Thirty-seven members were present at this meeting.

H. A. THOMAS, *Clerk.*

FEBRUARY 18, 1942.—A Joint Meeting of the Society and the Hydraulics Section was held at the Engineers Club and attended by seventy-two members and guests this evening. President Albert Haertlein presided. Chairman Stanley M. Dore gave the report of the nominating committee; the following officers for the year were elected.

Chairman—George N. Bailey
Vice-Chairman—William F. Covil
Clerk—Harold A. Thomas, Jr.
Executive Committee—Clarence R. Bliss, E. B. Cobb and L. M. Gentleman

The speaker for the evening was Mr. William G. Hoyt, Principal Hydraulic Engineer of the U. S. Geological Survey, who talked on the subject of "Some Unusual Features of Floods in the United States". In the course of his talk, Mr. Hoyt discussed the recent Report of the Committee on Floods. The speaker's wide knowledge of the field and his comparison of the flood problem in New England with that in other parts of the country made his talk very interesting. Several members of the Committee on Floods including the chairman, Howard M. Turner, participated in the discussion that followed.

The meeting was adjourned with a rising vote of thanks to the speaker.

HAROLD A. THOMAS, JR., *Clerk.*

APPLICATIONS FOR MEMBERSHIP

[April 20, 1942]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

DAVID M. BROWN, Hingham, Mass. (b. November 20, 1892, Boston, Mass.) Graduated from Northeastern University in 1915. Experience, 1915, Aspinwall & Lincoln, Boston, Mass., transitman; 1916-1921, Hood Rubber Company, Watertown, Mass., field engineer, lines, grades, inspection, design, supervision buildings, sewer, water, roads, etc.; 1921-1926, partner Luce & Brown, architects and engineers, general architectural and engineering practice; 1926-1930, superintendent for Olmsted Brothers on Fishers Island, New York, in charge of the construction of piers, boat and bath-houses, roads, sewage systems, grading, country residences, etc.; 1930-1933, mostly unemployed; 1933-1936, engineer National Park Service design and construction of roads, small bridges, dams; 1936-1938, engineer for George P. Carver, engineering company, Boston, Mass., supervision, marine construction, coal plants, estimating: 1939 to present, Fay, Spofford and Thorndike, Boston, Mass., resident engineer, drafting, estimating, design, supervision of construction. Refers to *K. R. Garland, W. L. Hyland, R. W. Horne, F. L. Lincoln, C. M. Spofford.*

Francis J. Crandall, Wellesley, Mass. (b. January 1, 1904, Albany, New York.) Graduated from Massachusetts Institute of Technology in 1927, B.S. degree. Experience, 1927-1929, Junior construction engineer building railroads, bridge piers, and other pertinent structures in the countries of Chile and Argentina, South America; 1929 held the position of engineering assistant in the Tunnel Division of New York working as a tunnel inspector in the section of the 8th Avenue subway under the East River from Fulton Street, New York City, to Furman Street, Brooklyn. Latter part of 1929 to the latter part of 1930 was superintendent of construction for Hageman & Harris Company of New York City. November, 1930, became President and Treasurer of the F. J. Crandall Corporation, engineering design and construction of foundations, bridges and buildings; 1933 obtained Professional Engineer's License #12382, issued by the New York State Educational Department to practice engineering in that state. This capacity carried on until 1935 at which time the above corporation became dormant by liquidation. 1936 became associated with the Liberty Mutual Insurance Company, as Civil Engineer and present capacity with this same organization is that of Assistant Chief Engineer in charge of all construction safety work covered by this insurance carrier. Refers to *J. D. Mitsch, H. S. Swartz, D. W. Taylor, J. B. Wilbur.*

H. Lowell Crocker, Framingham, Mass. (b. July 30, 1913, Boston, Mass.) Graduated from Tufts College in 1938. Experience: summers 1930, 1931, 1932, Junior Engineering Aid, Mass. Department of Public Works; January, 1933, to December, 1933, with Mass. Department of Public Works; May to September, 1932, general foreman, highway construction, New Haven Road Construction Company; May to September, 1936, with Mass. Department of Public Works, sidewalk construction, drainage and retaining walls; summer of 1937, with A. R. Romasello, as engineer on road construction; June, 1938, to February, 1940, with Mass. Department of Public Works; October, 1940 to June, 1941, with C. T. Main, Inc., on water and sewer construction at Camp Edwards; June, 1941 to July, 1941, with Town of Braintree, as engineer in Sewer Department; at present with Shreve, Lamb & Harmon & Fay, Spofford & Thorndike, on highway and railroad design and calculations. Refers to *A. B. Appleton, T. C. Coleman, G. A. Graves, F. L. Heaney.*

George C. Douglas, Melrose, Mass. (b. January 12, 1907, Boston, Mass.) Graduate of Northeastern University Evening Polytechnic School with Diploma in Civil Engineering, class of 1929. Experience, various experiences in Engineering work dating back to 1924. April, 1936 to July, 1937, with Morton C. Tuttle Company as Field Engineer; August, 1937 to December, 1937, with Stone & Webster as a concrete designer and detailer; January, 1938 to January, 1939, with several Boston Contractors on a part time basis as an estimator; January, 1939 to

April, 1939, with Metcalf & Eddy as engineering draftsman; April, 1939, to June, 1939, with Whitney Engineering Company as draftsman; July, 1939 to October, 1939, with F. W. Woolworth Company as structural designer and draftsman; January, 1940 to April, 1940, with Whitney Engineering Company as structural designer and draftsman; April, 1940, to June, 1940, with Metcalf & Eddy, as engineering draftsman; June, 1940 to April, 1942, employed by Fay, Spofford & Thorndike, as engineering draftsman. Refers to *A. S. Coombs, H. G. Dresser, K. R. Garland, F. L. Lincoln.*

Chester H. Minehan, Boston, Mass. (b. May 14, 1911, Worcester, Mass.) Graduated from Worcester Polytechnic Institute in 1936, Civil Engineering course. Experience, 1936-1939, engaged in land surveying; August, 1939-April, 1941, employed as draftsman in the U. S. Engineer Office of the War Department, in construction of flood control structures at Northampton, Mass., in addition to regular duties served as assistant to the office engineer. April, 1941, to date, engaged as junior hydraulic engineer in the Water Resources Branch of the U. S. Geological Survey, Department of Interior, Boston, Mass. Refers to *W. L. Isherwood, H. G. Kinnison, L. W. Lenfest, G. K. Wood.*

George T. Rooney, Brighton, Mass. (b. January 3, 1891, Lynn, Mass.) Graduated from Massachusetts Institute of Technology in 1916. Experience, January, 1916-March, 1917, instrument man, inspector, chief inspector, East River Tunnel Division, Public Service Commission, New York; March, 1917-August, 1917, field engineer, Power Plant Construction, Atlantic Refining Company, Philadelphia, Pa.; August, 1917-June, 1918, designer and assistant resident engineer, Hydr-electric Plant, H. K. Cooper & Company; June, 1918-July, 1919, resident engineer, U. S. Housing Project, Bridgeport, Conn.; July, 1919-June, 1920, chief party and designer, St. Lawrence River Hydro-electric development, J. L. Cooper & Company Engineers; June, 1920-October, 1940, estimator, designer and general superintendent, The Scully Company, Building Contractors, Cambridge, Mass.; October, 1940 to present time construction manager and Vice-President, The Scully Construction Company, Cambridge, Mass. Refers to *E. F. Allbright, R. H. Lindgren, J. S. Crandall, F. P. Scully.*

Norman P. Spofford, Beverly, Mass. (b. March 25, 1911, Danvers, Mass.) Received B. S. in Civil Engineering and M.S. in Railway Operation, from Massachusetts Institute of Technology, in 1934. Experience, after graduation, for 11 months, was with the U. S. Engineers on hydrographic surveying in Boston and Portland Harbors. For eight months, at the U. S. Hydraulic Waterways Experiment Station in Vicksburg, Mississippi, on model operation and construction. July, 1936, entered the employ of the Boston & Maine Railroad, and for five years was in the accounting department on cost studies and research. The past seven months has been in the Electrical Engineer's Office on electrical and piping design. Refers to *J. B. Babcock, C. B. Breed, J. P. Cronin, W. F. Cummings, H. F. Legro.*

Erik Per Sorensen, Brookline, Mass. (b. February 28, 1914, Copenhagen, Denmark.) Graduated from Royal Technical College, Copenhagen, in 1936, with B.S. in Civil Engineering. Experience: 1937, design engineer at Christiani & Nielsen, Ltd., Copenhagen, Denmark; 1938, design engineer at E. Rathgeb, Eng. Zurich, Switzerland; 1938-1939, graduate student at Harvard University (Spec. Soil Mechanics and

Theory of Elasticity); 1939, design engineer, Stone & Webster, Boston; 1939-1941, design engineer, Chas. T. Main, Inc., Boston; 1942, structural engineer, Chas. T. Main, Inc., Boston. Refers to *A. Casagrande, R. E. Fadum, L. G. Ropes, H. M. Westergaard.*

Transfer from Grade of Student

PAUL C. DANFORTH, Danvers, Mass. (b. April 30, 1916, Danvers, Mass.) Northeastern University from 1934 to 1937, Civil Engineering Course. Experience, two years spent with Aspinwall & Lincoln's successor, William S. Crocker, Boston, Mass., as rodman, instrumentman, and chief of party. (These two years were for the most part during the periods of cooperative work; 3 months in 1937 spent with Raymond Concrete Pile Co.; 1938, with A. G. Tomasello & Son, Inc., Boston; 1939 to May, 1941, with Department of Public Works, Division of Waterways, Commonwealth of Massachusetts. At present on active duty as Ensign, U. S. Naval Reserve, on the USS West Point. Refers to *C. O. Baird, E. A. Gramstorff, E. N. Hutchins, H. A. Mohr, F. W. Towers.*

WALTER B. KELLEY, Dorchester, Mass. (b. October 31, 1919, Boston, Mass.) Graduated from Northeastern University in 1941, B.S. degree in Civil Engineering. Experience, June, 1937-June, 1941, Junior engineering aid by the Metropolitan District Water Supply Commission, under Northeastern University's cooperative plan. July, 1941, to date employed as student engineer by the American Telephone and Telegraph Company, engaged in the construction, testing, and operation of long-distance telephone cables and associated equipment. Refers to *C. O. Baird, S. M. Dore, A. E. Everett, E. A. Gramstorff, K. R. Kennison.*

ARTHUR M. O'CONNOR, JR., Lynn, Mass. (b. October 2, 1917, Saratoga Springs, New York). Graduated from Northeastern University in June, 1941, with B.S. degree in Civil Engineering. Experience, April, 1939, to July, 1939, assistant inspector, Whitman & Howard; September, 1939, to November, 1940, engineering aid, Public Works Department, Stoneham, Mass.; January, 1941, to April, 1941, Instrument Man, General Electric Company River Works. At present Field Clerk, with Raymond Concrete Pile Company. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff, H. A. Mohr.*

*For Admission**

FRANCIS J. ALVES, Provincetown, Mass. (b. January 18, 1907, Provincetown, Mass.) Graduated from Provincetown High School in 1926. Enrolled in the Civil Engineering course of Rensselaer Polytechnic Institute for two years, 1926-1928. Experience: 1928 to 1929, employed by the New York State Division of Engineering at their cement testing laboratory at Albany, New York. 1929 to 1932, attended Northeastern University, Boston, Mass., and graduated with a B.S. degree in Civil Engineering. While at Northeastern employed as a rodman in the city of Newton Engineering Department. 1932 to present time have been engaged in private practice as a surveyor in Provincetown, Mass. Refers to *C. O. Baird, J. R. Dyer, E. A. Gramstorff, A. Q. Robinson, L. T. Schofield.*

CARL H. CRAWFORD, Natick, Mass. (b. May 24, 1911, Framingham, Mass.) Graduated from Northeastern University, in 1934, with B.S. Degree in Civil Engineering. Experience: 1930 to date with the Metropolitan District Water Supply Commission, on the construction of Quabbin Reservoir and Pressure Aqueduct. Refers to *S. M. Dore, D. O.*

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*Names not printed in January Journal.

Fisher, C. J. Ginder, P. Howard, K. R. Kennison.

Edward C. Drake, Malden, Mass. (b. September 9, 1905, Boston, Mass.) Completed 3 year course, 1929-1931, Franklin Union Technical School. Experience, 1926-1932, with Charles H. Tenney & Company, Boston, Mass., as draftsman to chief of party; 1933-1935, Rendle Corporation as assistant engineer; 1936, M. C. Hanson Company, as superintendent and estimator; 1936, F. A. Barbour, as surveyor; 1938, Raymond Concrete Pile Company, as engineer on pile layout; 1939 to date, with Metropolitan District Water Supply Commission, survey, drafting, chief of party on construction and topography. Refers to, *J. F. Brittain, S. M. Dore, D. O. Fisher, C. J. Ginder, K. R. Kennison.*

Donald J. Fogarty, Mattapan, Mass. (b. October 24, 1917, Saugus, Mass.) Graduated from Boston English High School in June, 1935. B.S. Degree in Civil Engineering from Tufts College Engineering School, June 1941. Experience, August, 1941, U. S. Geological Survey, Water Resources Branch, Boston district, as recorder. At present, Junior Hydraulic Engineer, U. S. Geological Survey, Water Resources Branch, Boston district, doing field and office work in connection with the determination and compilation of stream flow data, and the maintenance of stream gaging equipment. Refers to *M. A. Benson, W. L. Isherwood, H. B. Kinnison, F. N. Weaver, G. K. Wood.*

Frederick E. Griffin, Andover, Mass. (b. August 6, 1901, Lawrence, Mass.) Attended grade schools and high school at Lawrence, Mass., and have three years credit in the School of Civil Engineering at Villanova College, Villanova, Pa. Experience. worked three years at Shawsheen Village and Lawrence on building and covered filter construction and survey work; 1926 to date, with the Metropolitan District Water Supply Commission, in the field and have worked on general surveying, tunnel building construction, sinking of caissons, construction of an hydraulic filled dike, road construction, manufacture of reinforced concrete pipe for the Pressure Aqueduct and computation of estimates. Refers to *W. F. Covil, S. M. Dore, C. J. Ginder, K. R. Kennison, W. H. Sears.*

Charles C. McDonald, Melrose, Mass. (b. December 16, 1907, Alpine, Tenn.) Graduated from University of New Mexico in 1929, B.S. Degree in Civil Engineering. Experience, July, 1929 to February, 1930, steel detailer with American Bridge Company, Gary, Indiana; March, 1930 to March, 1935, Junior Engineer (hydraulics) with U. S. Geological Survey in Arizona, doing general stream gaging structures; April, 1935 to September, 1936, Assistant Engineer, U. S. Geological Survey in Arizona. Stream gaging work, office computation and field work in relation to stream flow determination; October, 1936 to July, 1939, some duties as above, in New York State, in addition, supervision of construction of 25 gaging stations, headquarters at Albany, New York; July, 1939, to October, 1941, associate hydraulic engineer in charge of sub-district office in Ellenville, New York. Direct supervision of work in obtaining stream flow and related data in Catskill Mountain Region; October, 1941, U. S. Geological Survey in Boston, Mass., as principal assistant to H. B. Kinnison, District Engineer, direct supervision of work in obtaining stream flow records in Massachusetts, New Hampshire, Vermont and Rhode Island. At present with U. S. Geological Survey Water Resources Branch, Post Office Building, Boston, Mass. Refer to *M. A. Benson, W. L. Isherwood, H. B. Kinnison, G. K. Wood.*

Robert W. Moir, Auburndale, Mass. (b. November 18, 1903, Auburndale, Mass.) 1922-1926, Massachusetts Institute of Technology. Experience, 1926 to present time with Metropolitan District Water Supply Commission, assistant civil engineer. Refers to *J. F. Brittain, S. M. Dore, S. M. Ellsworth, L. M. Gentleman, C. J. Ginder, K. R. Kennison.*

James C. M. Tillinghast, Belmont, Mass. (b. March 21, 1900, Towanda, Penn.) Graduated from Tufts College in 1924. Experience, 1926 to present with Metropolitan District Water Supply Commission on design and studies. Resident engineer for 60-inch concrete pipe line at Spot Pond during 1939-1940. Refers to *J. F. Brittain, S. M. Dore, L. M. Gentleman, C. J. Ginder, K. R. Kennison.*

ADDITIONS

Members

Francis J. Alves, 73 Franklin Street, Boston, Mass.

Ralph E. Fadum, 111 Pierce Hall, Harvard University, Cambridge, Mass.

Frederick S. Gibbs, 346A Newbury Street, Boston, Mass.

Charles C. McDonald, 122 Rowe St., Melrose, Mass.

Frederick E. Griffin, 25 Bartlett St., Andover, Mass.

William S. Mariner, 225 Dedham St., Dover, Mass.

Albert E. Sanderson, Box 83, Wayland, Mass.

Arpad Warlam, 3 Craigie Circle, Cambridge, Mass.

Alan K. Willard, 1 Kirk Street, Nashua, N. H.

Paul A. Wirth, 60 Pine Street, Mansfield, Mass.

Juniors

Norman B. Cleveland, 9 Ray St., Beverly, Mass.

Penneth M. Cline, 37 Howland St., Roxbury, Mass.

Henry G. Seeley, 428 East Eighth St., South Boston, Mass.

Students

Allen W. Abbott, 27 Lloyd Street, Winchester, Mass.

Peter Andrews, 105 Johnson Street, Springfield, Mass.

Richard Biggs, 18 Temple Avenue, Winthrop, Mass.

Henry J. Bishop, 606 County Street, New Bedford, Mass.

Charles W. Blanchard, 5 Ravenscroft Road, Winchester, Mass.

Walter Bodnar, 16 Highland Park Avenue, Roxbury, Mass.

David Bornstein, 24 Audubon Road, Milton, Mass.

Richard M. Burbank, 25 Hartsuff Street, Rockland, Mass.

Joseph Capone, Jr., 380 Beech Street, Roslindale, Mass.

Paul A. Caputo, Jr., 62 Arborway, Jamaica Plain, Mass.

Patrick J. Cosgrove, 22 Court Street, Dedham, Mass.

Robert J. Coughlin, 11 Upland Road, Medford, Mass.

Edward M. Cummings, 624 East Street, Ludlow, Mass.

Bradford Graves, R. F. D. East Pepperell, Mass.

John F. Heaney, 31 Chase Avenue, Lexington, Mass.

Harry C. Hunt, 28 Hale Street, Leominster, Mass.

John W. Ireland, 36 Newhall Street, Lynn, Mass.

Wilder E. Kelle, Jr., 133 Rockland Street, Canton, Mass.

Esa M. Khoury, 135 Hudson Street, Boston, Mass.

Robert N. Kuehn, 436 Mammoth Road, Manchester, N. H.

Edward R. Lamb, 109 Sewall Avenue, Brookline, Mass.
Joseph C. Lawler, 89 Empire Street, Lynn, Mass.
James R. Lowell, Jr., 160 Pearl Street, Newton, Mass.
Alan Levy, 120 Shore Drive, Winthrop, Mass.
James G. Makrys, P. O. Box 294, Onset, Mass.
Murray Marks, 55 Grove Street, Chelsea, Mass.
Peter A. Moldauer, 76 Quint Avenue, Allston, Mass.
Richard W. Newcomb, 1 Dexter Avenue, Waltham, Mass.
Carl R. Paladino, 8 Martyn Street, Waltham, Mass.
Samuel J. Pattison, Jr., 122 East Side Parkway, Newton, Mass.
Walter A. Petrocelli, 138 Hutchinson Street, Revere, Mass.
Lawrence I. Piper, 2 Greenough Avenue, Jamaica Plain, Mass.
Charles L. Pistorino, 88 Auckland Street, Dorchester, Mass.
Lee E. Pray, 18 Cumberland Street, Boston, Mass.
Leon E. Rasanen, 132 Roosevelt Avenue, Norwood, Mass.
Viljo W. Rekola, Box 130, Brooklyn, Connecticut
Elmer E. Smith, 181 Marlborough Street, Boston, Mass.
Richard E. Sprague, 24 Neponset Road, Quincy, Mass.
Roderick Van Tuyl, Greenport, New York.
Robert S. Wharton, 254 Franklin Street, Framingham, Mass.
Gordon G. Woods, 86 St. Stephen Street, Boston, Mass.

DEATHS

William J. Backes, January 20, 1942
Robert S. Hale, December 31, 1941
Austin B. Mason, February 5, 1942
Franklin A. Snow, March 17, 1942

ANNUAL REPORTS

REPORT OF BOARD OF GOVERNMENT FOR THE YEAR 1941-1942

Boston, Mass., March 18, 1942

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the By-Laws, the Board of Government presents its report for the year ending March 18, 1942.

Membership

Fourteen new members, 2 juniors, and 40 students have been added during the year, and 2 members, 4 juniors have been reinstated, making a total addition of 62 members.

During the year 11 members have died, 15 have resigned, 3 members have had dues remitted and resignations accepted, 27 members have been dropped for non-payment of dues making a total deduction of 56.

The present net membership of the Society consists of 7 honorary members, 602 members, 39 juniors, 94 students, 7 associates, making a total membership of 749, a net gain for the year of 4.

The honorary membership list is as follows:

Charles T. Main, elected January 28, 1932
Dr. Karl T. Compton, elected February 17, 1932
Prof. C. Frank Allen, elected March 16, 1932
Joseph R. Worcester, elected February 21, 1934
Charles M. Allen, elected January 14, 1942
Arthur W. Dean, elected January 14, 1942
Charles R. Gow, elected January 14, 1942

Deaths

Members:

T. T. Hunter Harwood, November 21, 1940
Charles A. French, April 6, 1941
Henry A. Varney, April 10, 1941
Henry C. Robbins, May 6, 1941
Raymond C. Allen, June 20, 1941
Sidney Smith, June 26, 1941
Louis F. Buff, August 20, 1941
Charles F. Fitz, July 11, 1941
Robert S. Hale, December 31, 1941
William J. Backes, January 20, 1942
Austin B. Mason, February 5, 1942

Remission of Dues and Extension of Time

During the year the Board of Government granted a number of members an extension of time for payment of dues and has remitted the dues of other members. With much regret the board voted this year to drop from membership those who had not paid their 1941 dues, for which an extension had been granted. The Board has remitted dues and accepted resignations from 3 members. In the case of 2 members, dues for the year ending March 18, 1942, have been remitted.

The Board has granted 18 members an extension of time for payment of dues for year ending March 18, 1942.

Exemption of Dues

Eighty-eight members are now exempt from dues in accordance with By-Laws 8, which provided that "a member of any grade who has paid dues for forty years, or who has reached the age of seventy years and has paid dues for thirty years, shall be exempt from further dues".

Meetings of the Society

Eight regular meetings, since the Annual, have been held during the year.

The October meeting was the Annual Student Night, attended by Student Chapters, American Soceity of Civil Engineers, at Harvard, Massachusetts Institute of Technology, Tufts, Brown University, Rhode Island State College, New Hampshire University, Worcester Polytechnic Institute and the Northeastern University Section of the Boston Society of Civil Engineers.

The total attendance at all meetings was 777 persons; the largest attendance was 225 and the smallest 54. Suppers have been a feature at all the meetings and they were well attended.

The papers and addresses given were as follows:

March 19, 1941. Annual meeting, Address of retiring President, Arthur L. Shaw, "Some Observations on Engineering for National Defense", followed by dinner and entertainment.

April 16, 1941. Joint Meeting, American Society of Civil Engineers, Northeastern Section, Boston Society of Civil Engineers and Society of American Military Engineers, Boston Post. A Symposium—"Some Engineering Features at Camp Edwards". Speakers, Col. Frank M. Gunby, Truman H. Safford, Samuel M. Ellsworth and Alfred Haigh.

May 21, 1941. "Recent Improvements in the Design of Suspension Bridge Cables", by Blair Birdsall, Assistant Chief Engineer of Bridge Department of the John A. Roebling's Sons Company, and a review of the general history and 100th anniversary of the John A. Roebling's Sons Company, by E. H. Peplow, Jr.

June 17, 1941. Excursion to Quabbin Reservoir. Unveiling of Memorial to the late Frank E. Winsor at Quabbin Reservoir. This was a joint excursion with the American Society of Civil Engineers, Northeastern Section.

September 24, 1941. Joint Meeting. Boston Society of Civil Engineers and Boston Post, Society of American Military Engineers. "Engineering, Economic and Military Components of Hemisphere Defense", by Major E. C. Harwood, Corps of Engineers, United States Army.

October 15, 1941. Student Night. Joint Meeting. Boston Society of Civil Engineers and American Society of Civil Engineers, Northeastern Section and Student Chapters A.S.C.E. and Northeastern University Section B.S.C.E. "Record Time Construction of Quonset Naval Air Station, R. I.," by Commander R. V. Miller, (C.E.C.) U.S.N.—Officer in Charge of Construction, Naval Air Station, Quonset, R. I.

November 26, 1941. Joint Meeting. Boston Society of Civil Engineers and Highway Section, B.S.C.E. "Post-War Highway Economics", by Charles M. Upham, Engineer—Director of the American Association of Road Builders.

December 17, 1941. Joint Meeting. Boston Society of Civil Engineers and Sanitary Section, B.S.C.E. "Delaware Water Supply System", by Roger W. Armstrong, Deputy Chief Engineer, Board of Water Supply, New York City.

January 14, 1942. Joint Meeting. Boston Society of Civil Engineers and Designers Section, B.S.C.E. "Cracks in Concrete", by Roy W. Carlson, Associate Professor of Civil Engineering at M.I.T.

February 18, 1942. Joint Meeting. Boston Society of Civil Engineers and Hydraulics Section B.S.C.E. "Some Unusual Features of Floods in the United States", by William Glenn Hoyt, Principal Hydraulic Engineer, U. S. Geological Survey, Dept. Interior Bldg., Washington, D. C.

Sections

Thirty-three meetings were held by the Sections of the Society during the year. These meetings of the Sections, offering opportunity for less formal discussion, have continued to demonstrate their value to their members and to the Society. The variety of subjects presented has made an appeal to the members, as indicated by the general attendance at these meetings.

Sanitary Section Meetings. The Sanitary Section has held 6 meetings during the year, with an average attendance of 43. The papers and meetings are listed in the report of the Executive Committee.

Designers Section Meetings. The Designers Section has held 7 meetings during the year, with an average attendance of 37. The papers and meetings during the year are listed in the report of the Executive Committee.

Highway Section Meetings. The Highway Section has held 2 meetings during the year, with an average attendance of 46. The papers and meetings are listed in the report of the Executive Committee.

Hydraulics Section Meetings. The Hydraulics Section held 3 meetings during the year, with an average attendance of 48. The papers and meetings are listed in the report of the Executive Committee.

Northeastern University Section Meetings. The Northeastern University Section held 15 meetings and excursions during the year with an average attendance of 42. The present membership includes 95 now in attendance in the University. The meetings held are listed in the report of the Executive Committee.

Journal

The report of the Editor of the JOURNAL for the calendar year 1941 will be printed in the April 1942, JOURNAL.

*Funds of the Society**

Permanent Fund. The Permanent Fund of the Society has a present value of about $60,000. The Board of Government authorized the use of as much as necessary of the current income of this fund in payment of current expenses.

John R. Freeman Fund. In 1925 the late John R. Freeman, a past President and Honorary member of the Society, made a gift to the Society of securities which was established as the John R. Freeman Fund, the income from which was about $1,400. The income from this fund is to be particularly devoted to the encouragement of young engineers. Mr. Freeman suggested several uses, such as the payment of expenses for experiments and compilations to be reported before the Society; for underwriting meritorious books or publications pertaining to hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to this Society; or establishing a traveling scholarship every third year open to members of the Society for visiting engineering works, reports of which would be presented to the Society. No additional scholarship was authorized during the year.

Edmund K. Turner Fund. In 1916 the Society received 1,105 books from the library of the late Edmund K. Turner, and a bequest of $1,000, "the income of which is to be used for library purposes". The Board voted to use $35 of the income for the purchase of books for the Library.

Alexis H. French Fund. The Alexis H. French Fund, a bequest amounting to $1,000, was received in 1931 from the late Alexis H. French of Brookline, a former Past President of the Society. The income of this fund is "to be devoted to the library of the Society". The Board voted to use $35 of the available income for the purchase of books for the library.

Desmond FitzGerald Fund. The Desmond FitzGerald Fund, established as a bequest from the late Desmond FitzGerald, a past President and honorary member of the Society, provided that the income from this fund shall "be used for charitable and educational purposes". The Board voted on April 7, 1941, to appropriate from the income of this fund the sum of $75, to be known as the Boston Society of Civil Engineers Scholarship in memory of Desmond FitzGerald, and to be given to a student of Northeastern University. Presentation of this Scholarship was made by President Albert Haertlein, at a student mass meeting at the University on April 23, 1941, to Walter B. Kelley, of Dorchester, Mass., a senior student in Civil Engineering.

Tinkham Memorial Fund. The "Samuel E. Tinkham Fund", established in 1921, at the Massachusetts Institute of Technology by the Society "to assist some worthy student of high standing to continue his studies in Civil Engineering", had a value of $2,428.39 on June 30, 1941. Mortimer W. Meyer, Jr., of South Orange, N. J., a senior student in Civil Engineering has been awarded this scholarship for the year 1941-1942.

Clemens Herschel Fund. This fund was established in 1931, by a bequest from the late Clemens Herschel, a former Past President and honorary member of the Society. The income from this fund is to be used for the presentation of prizes for particularly useful and commendable papers presented at meetings of the Society. The present value of this fund is about $1,000. The expenditure made during the year from this fund was for prizes.

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*Details regarding the values and income of these funds are given in the Treasurer's report.

Edward W. Howe Fund. This fund, a bequest of $1,000, was received December 2, 1933, from the late Edward W. Howe, a former Past President of the Society. No restrictions were placed upon the use of this money, but the recommendation of the Board of Government is that the fund be kept intact, and that the income be used for the benefit of the Society or its members. No expenditure from this fund was made during the year.

Desmond FitzGerald Medal. The Desmond FitzGerald Medal (bronze) was provided for in 1910 as an endowed prize by the late Desmond FitzGerald, a former Past President and honorary member of the Society. The prize is awarded annually to a member who presents an original paper to the Society which is published in the JOURNAL for the current year.

In accordance with the recommendation of the Committee on Awards, the Board of Government voted to award a Desmond FitzGerald Medal to each, Howard M. Turner and Allen J. Burdoin, co-authors, members, for their paper, "The Flood Hydrographs", presented at a meeting of the Hydraulics Section on May 7, 1941, and published in the July, 1941, JOURNAL.

Section Prizes

The Board of Government voted on April 12, 1924, to present a prize for a worthy paper given in each section by a member of that section, "this award to consist of books suitably inscribed".

Designers Section Prize. The Board adopted the recommendation of the Designers Section Prize Award Committee and voted that the Designers Section Prize be awarded to Edwin B. Cobb and Chester J. Ginder (co-authors) members, for their paper on "Design of Fabricated Plate Steel Tees, Laterals and Wyes of Large Diameters for the Pressure Aqueduct of the Boston Metropolitan District Water Supply Commission", presented at a meeting of the Designers Section held on November 14, 1940, and published in the April, 1941, JOURNAL. The prize consisted of the following books:

"Handbook of Hydraulics". Horace Williams King.
"Handbook of Engineering Fundamentals". Ovid W. Eshbach.
"Sewage Treatment". Karl Imhoff and Gordon M. Fair.
"Strength of Materials". S. Timoshenko.
"Hydraulics of Steady Flow in Open Channels". Sherman M. Woodward and Chesley J. Posey.

Northeastern University Section Prize. The Board of Government voted on March 10, 1931, to provide for the award of a prize to a member of the Northeastern University Section.

The Board adopted the recommendation of the Committee on Awards and voted that the Northeastern University Section Prize be awarded to Warren T. Boutelle, for his paper on "Sewage Treatment at Camp Edwards", presented at a meeting of students chapters held on May 21, 1941. The prize consisted of the following books:

"Water Works Handbook of Design, Construction and Operation". Alfred D. Flinn, Robert Spurr Weston and Clinton L. Bogart.
"Handbook of Hydraulics". Horace Williams King.
"Concrete Engineer's Handbook". George A. Hool, Nathan C. Johnson, S. C. Hollister.

Social Activities

Five of the regular meetings were held at the Engineer's Club; one held at the New Lecture Hall, Harvard University, one held at the Boston City Club and one held at Walker Memorial Bldg., M.I.T., preceded by suppers, under direction of the Social Activities Committee. As usual the most enthusiastic meeting was Student Night, held in October, and attended by members of the Student Engineering Societies of Massachusetts Institute of Technology, Harvard University, Tufts, Rhode Island State College, Brown University, Worcester Polytechnic Institute, University of New Hampshire and Northeastern University Section of the Boston Society of Civil Engineers. An excursion to Quabbin Reservoir was made on June 17, 1941, attended by 175.

Library

The report of the Committee on Library contains a complete account of the library activities during the past year.

Society Activities

The usual special committees dealing with the general activities and conduct of the Society have included the following: Program, Publication, Membership, Library, Social Activities, Relations of Sections to Main Society. Other special committees have included the following: 1936 Floods, Subsoils of Boston, Desmond FitzGerald and other prizes, the Welfare Committee, Investments, the John R. Freeman Fund and the Committee on Headquarters. Each of these Committees has made a distinct contribution to the Society and has developed fields of endeavor which will prove a great benefit to the members.

The Society has co-operated with the Engineering Societies of New England, and many members of the Society have served on Engineering Societies' Committees.

Your Board, in conclusion, wishes to express its appreciation of the excellent work done by the officers of the Sections and by the Committees of the Society.

Albert Haertlein, *President.*

REPORT OF THE TREASURER

Boston, Mass., March 18, 1942

To the Boston Society of Civil Engineers:

The financial standing of the Society on March 6, 1942, at the close of the fiscal year is shown in the following:

Table 1. Distribution of Funds—Receipts and Expenditures from March 10, 1941 to March 6, 1942
Table 2. Record of Investments

Mr. Charles L. Coburn, former Treasurer, whose work now requires his residence in Rhode Island, tendered his resignation from that office on December 17, 1941, and it was accepted by the Board of Government as of that date. On January 14, 1942, I was elected Treasurer to fill the unexpired term of Mr. Coburn, and have served in that capacity from that time.

The Board of Government authorized a complete audit of the finances of the Society as of December 17, 1941. This was done and the audit is on file in the records of the Society.

The receipts from dues amounted to $4,876, which is about the same as has been realized from this source in other recent years. However, it has been necessary to transfer $1,002.57 from the income of the Permanent Fund to the Current Fund to take care of the deficit from current operations, as expenses exceeded current income for the year.

Bonds and stocks sold or matured during the year resulted in a loss of $1,729.04 in the book value of our holdings. However, it was considered advisable to sell certain of the securities and the proceeds were used to purchase $8,000 of United States Savings Bonds, Series G.

Due to the sale of depreciated securities, the book value of the Assets of the Society is not quite as favorable as it was a year ago, although the return on investments in dollars was almost the same as for the previous year. The total book value of all securities and cash is $705.31 less than the total a year ago.

The Permanent Fund now amounts to $61,080.11.

The amounts transferred from the Permanent Fund during the last five years are shown in the following table:

	1937-38	1938-39	1939-40	1940-41	1941-42
Total expenditures from the Current Fund, less receipts, other than from dues and from investments	$6,622	$5,860	$5,860	$5,345	$5,878
Receipts from dues	4,886	4,874	4,853	4,961	4,876
Tranfers from income of Permanent Fund	$1,736	$986	$1,007	$384	$1,002

The following table shows the comparative book values of the two principal funds at the close of each year and the ratio of market to book values. It should be kept in mind that the value of the Freeman Fund is largely dependent upon expenditures made from this fund during the year. The growth of the Permanent Fund is affected not only by the percentage of return on investments but also by the amounts it has been necessary to transfer from the income of this fund to meet current expenses.

	Mar. 10 1938	Mar. 10 1939	Mar. 10 1940	Mar. 10 1941	Mar. 6 1942
Permanent Fund	$55,064	$56,672	$58,138	$60,527	$61,080
John R. Freeman Fund	$26,679	$26,949	$26,522	$27,666	$26,528
Market Value in per cent of Book Value	84:17%	92.75%	92.28%	87.92%	83.44%

The following table will show for the past five years the book values of securities and bank deposits and the total value of all holdings not including the value of the library and physical property.

	Mar. 10 1938	Mar. 10 1939	Mar. 10 1940	Mar. 10 1941	Mar. 6 1942
Bonds	$33,198.71	$32,279.96	$32,524.96	$30,782.49	$31,610.49
Co-operative Banks	13,585.21	15,041.52	16,512.94	17,971.92	19,490.68
Stocks	41,747.17	41,747.17	41,747.17	44,957.17	43,967.17
Cash	1,049.65	2,454.98	1,767.45	2,428.01	365.94
TOTAL	$89,580.74	$91,523.63	$92,552.52	$96,139.59	$95,434.28

In addition to the Treasurer's cash balance of $365.94, the Secretary has a "change fund" of $30.00, which should be included to show total assets.

Respectfully submitted,

CHESTER J. GINDER, *Treasurer.*

TABLE 1.—DISTRIBUTION OF FUNDS—RECEIPTS AND EXPENDITURES

	Book Value March 10, 1941	Interest and Dividends	Net Profit (or loss) at Sale or Maturity	Transfer of Funds		Book Value March 6, 1942
				Purchased	Sold	
Bonds	$30,782.49	$1,118.95	$1,419.78	$8,603.00	$6,415.22	$31,610.49
Co-operative Banks	17,971.92	516.26		1,518.76		19.490.68
Stocks	44,957.17	2,073.62	309.26		680.74	43,967.17
					Net Decrease	
Cash Available for Investment	928.01				2,062.07	—1,134.06†
Totals (except Current Fund)	$94,639.59	$3,708.83	$1,729.04	$10,802.04	$9,158.03	$93,934.28

	Book Value March 10, 1941	Allocation of the Above		Miscel. Receipts	Miscel. Expenditures	Book Value March 6, 1942
		at 3.919%	at 1.827%			
Permanent Fund	$60,527.49	$2,372.01	$1,105.82	$ 289.00	$1,002.57	$61,080.11
John R. Freeman Fund	27,666.13	1,084.20	505.45		1,716.87	26,528.01
Edmund K. Turner Fund	1,006.50	39.44	18.39		51.58	975.97
Desmond FitzGerald Fund	1,982.51	77.69	36.22		90.05	1,933.93
Alexis H. French Fund	1,024.71	40.16	18.72		13.88	1,032.27
Clemens Herschel Fund	1,247.29	48.89	22.79		61.53	1,211.86
Edward W. Howe Fund	1,184.96	46.44	21.65		37.62	1,172.13
	$94,639.59	$3,708.83	$1,729.04	$ 289.00	$2,974.10*	$93,934.28
Current Fund	1,500.00			8,738.27*	8,738.27	1,500.00
Totals	$96,139.59	$3,708.83	$1,729.04	$9,027.27*	$11,712.37*	$95.434.28

*Includes transfer of $1,002.57 from the income of the Permanent Fund to the Current Fund.
†Represents Current Fund Cash used for investment.

TABLE 2—RECORD OF INVESTMENTS

	Date of Maturity or Classification	Fixed or Current Interest Rate	During the Year March 10, 1941 to March 6, 1942		Sold or Matured		March 6, 1942		
			Interest Received	Additional Amount Invested	Amount Received	Profit (or Loss)	Par Value	Book Value	Market Value
BONDS									
American Telephone & Telegraph Co.	Sept. 1, 1956	3 %	$ 9.00	$603.00	....	..	$ 600.00	$ 603.00	$ 640.50
Baltimore & Ohio RR Co.	Aug. 1, 1944	4 %	80.00	....	....	..	2,000.00	2,013.75	1,460.00
Canadian Pacific RR	July 2, 1949		152.50	....	....	..	5,000.00	5,342.50	3,937.50
Chicago & Northwestern Ry. Co.	Nov. 1, 1987	5 %	....	....	$ 234.33	—$ 868.17	....	....	....
The Cleveland Union Term Co.	Apr. 1, 1973	5 %	33.61	....	761.82	— 236.93	....	....	....
The Cleveland Union Term Co.	Oct. 1, 1977	4½%	30.25	....	686.82	— 293.18	....	....	....
Eastern Mass. Street Railway	Jan. 1, 1948	4½%	45.00	....	....	..	1,000.00	1,022.50	1,045.00
Illinois Power and Light Co.	Dec. 1, 1956	5 %	25.28	....	1,064.31	— 83.06	....	....	....
Louisiana Power & Light Co.	Dec. 1, 1957	5 %	25.28	....	1,076.81	— 241.81	....	....	....
Mississippi Power & Light Co.	Dec. 1 , 1957	5 %	25.28	....	1,036.81	64.31	....	....	....
Penn. Central Light & Power Co.	Nov. 1, 1977	4½%	45.00	....	....	..	1,000.00	1,052.89	1,028.75
The Pennsylvania Railroad Co.	June 1, 1965	4½%	45.00	....	....	..	1,000.00	1,017.74	1,041.25
The Pennsylvania Railroad Co.	Apr. 1, 1970	4½%	45.00	....	....	..	1,000.00	971.58	905.00

TABLE 2—RECORD OF INVESTMENTS—*Continued.*

	Date of Maturity or Classification	Fixed or Current Interest Rate	During the Year March 10, 1941 to March 6, 1942				March 6, 1942		
					Sold or Matured				
			Interest Received	Additional Amount Invested	Amount Received	Profit (or Loss)	Par Value	Book Value	Market Value
Peoria Water Works Co.	Aug. 1, 1950	5 %	23.75	....	1,010.00	..	....	....	....
Puget Sound Power & Light Co.	June 1, 1949	5½%	55.00	....	....	..	1,000.00	1,025.00	1,000.00
Southern Pacific Co.	Mar. 1, 1977	4½%	$11.50	....	$544.32	$410.68	....	....	....
Standard Oil Co. of N. J.	July 1, 1953	2¾%	27.50	....	....	..	$1,000.00	$1,021.25	$1,045.00
Texas Electric Service Co.	July 1, 1960	5 %	100.00	....	....	..	2,000.00	2,000.00	2,132.50
The Toledo Edison Co.	July 1, 1968	3½%	70.00	....	....	..	2,000.00	2,092.50	2,137.50
Union Pacific RR Co.	June 1, 1980	3½%	70.00	....	....	..	2,000.00	2,125.00	2,085.00
United States Savings Bonds, Series D	Jan. 1, 1950		60.00	....	....	..	3,000.00	2,340.00	2,340.00
United States Savings Bonds, Series G	June 1, 1953	2½%	62.50	5,000.00	....	..	5,000.00	5,000.00	5,000.00
United States Savings Bonds, Series G	June 1, 1953	2½%	37.50	3,000.00	....	..	3,000.00	3,000.00	3,000.00
Western Maryland RR Co.	Oct. 1, 1952	4 %	40.00	....	....	..	1,000.00	982.78	907.50
TOTALS			$1,118.95	$8,603.00	$6,415.22	$1,419.78	$31,600.00	$31,610.49	$29,705.50

TABLE 2—RECORD OF INVESTMENTS—*Continued.*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 10, 1941 to March 6, 1942					March 6, 1942	
					Sold or Matured				
			Dividends Received	Additional Amount Invested	Amount Received	Profit (or Loss)	Number of Shares	Book Value	Market Value
CO-OPERATIVE BANKS									
Codman Co-operative Bank	Series 37	3½%	$129.40	$ 349.40	....	..	20	$ 3,946.20	$ 3,946.20
Merchants Co-operative Bank	Series 145	3 %	180.80	660.80	....	..	40	7,687.60	7,687.60
Suffolk Co-operative Bank	Series 134	3 %	178.56	508.56	....	..	30	6,856.88	6,856.88
Suffolk Co-operative Federal Savings & Loan Assoc. of Boston, Mass.	Matured Shares	3 %	27.50	....	....	..	5	1,000.00	1,000.00
TOTALS			$516.26	$1,518.76	....	..		$19,490.68	$19,490.68

TABLE 2—RECORD OF INVESTMENTS—*Continued.*

			During the Year March 10, 1941 to March 6, 1942					March 6, 1942	
					Sold or Matured				
	Date of Maturity or Classification	Fixed or Current Dividend Rate	Dividends Received	Additional Amount Invested	Amount Received	Profit (or Loss)	Number of Shares	Book Value	Market Value
STOCKS									
American Tel. & Tel. Co.	Common	$ 9.00	$ 414.00	....	....	..	46	$5,346.04	$5,566.00
Bankers Trust Co., N. Y.	Common	2.00	60.00	....	....	..	30	1,590.00	1,035.00
Central Hanover Bank & Trust Co. of N. Y.	Common	3.00	120.00	....	....	..	30	3,210.00	2,040.00
Commonwealth & Southern Corp., Ltd.	Cum. Pfd.	3.00	24.00	....	....	..	8	1,019.89	248.00
Commonwealth & Southern Corp.	Common	....	....	....	....	..	25		9.81
Commonwealth & Southern Corp.	Opt. Warrants....		....	....	....	..	12		
Consolidated Edison (Gas) Co. of N. Y.	Common	2.00	36.00	....	....	..	20	1,906.50	250.00
General Electric Co. of N. Y.	Common	1.85	87.50	....	....	..	50	2,341.47	1,225.00
Hartford Fire Insurance Co.	Common	2.50	25.00	....	....	..	10	761.25	827.50
The Home Insurance Co., N. Y.	Common	1.60	49.60	....	....	..	31	1,245.00	895.13
Minnesota Power & Light Co., Minn.	Pref.	7.00	70.00	....	....	..	10	980.00	830.00
National Dairy Products Co.	Common	.80	40.00	....	....	..	50	1,154.74	681.25
National Fire Insurance Co.	Common	2.00	40.00	....	....	..	20	1,240.00	1,122.50

TABLE 2—RECORD OF INVESTMENTS—*Continued.*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 10, 1941 to March 6, 1942				March 6, 1942		
					Sold or Matured				
			Dividends Received	Additional Amount Invested	Amount Received	Profit (or Loss)	Number of Shares	Book Value	Market Value
New England Power Assoc.	Pref.	6.00	80.00	....	....	..	20	1,815.00	585.00
New York Central R. R.	Common	....	....	....	....	..	10	870.45	82.50
North American Trust Shares	Jul. 15, '55	13.6	213.00	....	....	..	1,500	5,342.00	3,030.00
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	$ 1.50	$ 103.26	....	....	..	60	$1,922.02	$2,040.00
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	1.37	14.26	....	....	..	20		
Pacific Gas & Elec. Co.	Common	2.00	128.00	....	....	..	64	1,808.79	1,088.00
Southern California Edison Co.	Cum Orig. Pfd.	1.90	70.00	....	....	..	40	1,161.22	1,480.00
Southern California Edison Co., Ltd.	Common	1.75	35.00	....	....	..	6	539.75	
Southern California Edison Co.	Common	1.75	....	....	....	..	14		350.00
Standard Oil Co.	Common	1.75	25.00	....	....	..	10	479.54	338.75
Tampa Electric Co.	Common	2.13	54.00	....	....	..	30	1,151.25	525.00
Timken Roller Bearing Co.	Common	3.00	60.00	....	....	..	15	1,018.97	558.75
Trimount Dredging Co.	Pref.	....	....	....	....	..	2	....	....
U. S. Smelting Refining & Mining Co.	Pref.	3.50	70.00	....	....	..	20	1,365.04	1,350.00
United States Steel Corp.	Common	3.00	40.00	....	....	..	10	860.75	495.00
United States Trust Co. of Boston	Conv. Pref.	.80	180.00	....	....	..	225	4,837.50	2,756.25
Utah Power & Light	Cum. Pref.	5.834	35.00	....	680.74	309.26			
TOTALS			$2,073.62		$680.74	$309.26		$43,967.17	$29,409.44

REPORT OF THE SECRETARY

Boston, March 16, 1942.

To the Boston Society of Civil Engineers:

The following is a statement of cash received by the Secretary, and of the expenditures approved by the President, in accordance with the Budget adopted by the Board of Government.

For the Year Ending March 18. 1942

Current Fund Account

	Account Number	Expenditures	Receipts
Office			
Secretary, salary and expense	(1)	$ 240.00	
Stationery, printing and postage	(2)	364.31	
Incidentals and Petty Cash	(3)	93.45	
Insurance and Treasurer's Bond	(4)	65.25	
Safety Deposit Box	(5)	12.10	
Quarters, rent, light and telephone	(7)	1,740.47	*$630.00
Office, clerical	(8)	1,360.00	
Auditors for 1941 accounts and Investment services	(9)	225.00	
Meetings			
Rent of halls	(11)	124.50	
Stationery, printing and postage	(12)	25.55	
Social Activities	(13)	134.29	59.55
Stereopticon and Reporting	(14, 15)	5.20	
Annual Meeting (March, 1941)	(16)	76.90	
Sections			
Sanitary Section	(21)	27.83	
Designers Section	(22)	27.50	
Highway Section	(23)	17.15	
Northeastern University Section	(24)	2.25	
Hydraulics Section	(25)	0.00	
Journal			
Editor, salary and expense	(31)	314.00	
Printing and Postage	(32)	2,147.83	
Reprints	(33)	674.00	
Advertising, commission and receipts	(34)	231.95	781.00
Sale of Journals and reprints	(35)		1,351.96
Library			
Librarian, salary and expense	(41)	53.11	
Periodicals	(43)	96.58	
Binding	(44)	33.15	

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*From ESNE, $600 and $30 from other tenant.

Fines on overdue books	(45)		6.10
Bank Charges	(53)	11.82	
Forward		$8,104.19	$2,828.61
Brought Forward		$8,104.19	$2,828.61
Dues to Engineering Societies of N. E.	(59)	602.22	
Dues from B.S.C.E. Members	(70)		4,875.99
Badges from Members	(51)	17.86	17.86
Binding Journals for Members	(52)	14.00	13.24
Transfer Income Permanent Fund to Current Fund			1,002.57
Total Current Fund, to be accounted for		$8,738.27	$8.738.27
Entrance Fees to Permanent Fund 14 new members; 2 juniors; 40 students; 4 juniors transferred to members; 7 students transferred to juniors; but, 1 new member and 1 junior transferred to members were exempt from payments of entrance fee and transfer fee.			$289.00

The above receipts have been paid to the Treasurer, whose receipts the Secretary holds. The Secretary holds cash amounting to $30, included as payment under Item 3 (Petty Cash), to be used as a fixed fund or cash on hand for making change at buffet suppers.

Respectfully submitted,

Everett N. Hutchins, *Secretary.*

REPORT OF THE AUDITING COMMITTEE

Boston, March 18, 1942.

We have reviewed the records and accounts of the Secretary and Treasurer of the Boston Society of Civil Engineers and are satisfied that they are correct and present accurately the receipts and expenditures for the year. Reference is made to the fact that the former Treasurer, Mr. Charles L. Coburn, resigned on December 17, 1941, and to the complete audit of these accounts which was made at that time by this Committee, and to the review and report by the Certified Public Accountant, Mr. William J. Hyde, which have been placed on file in the records of the Society.

Thomas R. Camp,
C. Frederick Joy, Jr.

Auditing Committee of the Directors of the Boston Society of Civil Engineers.

REPORT OF THE EDITOR

Boston, Mass., January 26, 1942.

To the Board of Government,
Boston Society of Civil Engineers:

The Journal for the calendar year 1941 (Volume XXVIII), was issued quarterly, in the months of January, April, July and October, as authorized by the Board of Government on December 20, 1935.

During the year 1941 there have been published thirteen papers presented at meetings of the Society and Sections, and one other technical article. The Table of Contents and Index for the year are included in the October, 1941, issue.

The four issues of the Journal contained 374 pages of papers and discussions, 7 pages of Index, and 47 pages of advertising, a total of 428 pages. An average of 1,137 copies per issue were printed. The net cost was $1,294.73 as compared with $1,023.31 for the preceding year.

The cost of printing the Journal was as follows:

Composition and printing		$1,535.98
Cuts		458.69
Wrapping, mailing and postage		83.02
Editing		300.00
Copyright		8.00
Total, gross cost of Journal		$2,385.69
Receipts from subscriptions and sales of Journals	$387.61	
Receipts, net from advertising	703.35	1,090.96
Net cost of Journal		$1,294.73

Last year the Board of Government authorized the publication in book form of reprints of papers on the subject of Soil Mechanics, printed in the Journal during the years 1925-1940. All of the 1,000 copies of this book entitled "Contributions to Soil Mechanics", containing 14 articles, were sold. The total receipts from the sales of this book amounted to $1,646.23, and the cost of printing was $1,004.95. This year the Board authorized the reprinting of another 1,000 copies at a cost of about $810. The total number of this new lot sold to December 31, 1941, was 371 copies.

Respectfully submitted,

Everett N. Hutchins, *Editor.*

REPORT OF THE COMMITTEE ON MEMBERSHIP

Boston, March 18, 1942.

To the Boston Society of Civil Engineers:

During the past year an effort has been made by this committee to increase the enrollment by sending a circular letter to every member of the Society requesting their cooperation in enlisting new members. This letter emphasized the opportunity for getting new members because of the increased activity of the engineering concerns and because of the ability of qualified candidates to meet the costs of joining the Society.

In response to this letter, twenty-four applications have been received by the Society and many of this group have already been admitted to membership. The remaining applications will be acted upon during the coming year.

The figures for new members during the past year are as follows:

New Members:	
Grade of Member	14
Grade of Junior	2
Grade of Student	40
Reinstated:	
Grade of Member	2
Grade of Junior	4
Total	62

The corresponding figure for this total last year was 44.

The committee wished to call attention to the very fine cooperation it received from the new treasurer, Mr. Chester J. Ginder, who was responsible for five applications for membership.

J. D. Mitsch, *Chairman.*

REPORT OF THE COMMITTEE ON SOCIAL ACTIVITIES

Boston, March 18, 1942.

To the Boston Society of Civil Engineers:

The Committee on Social Activities submits the following report for the year 1941-42.

Five regular meetings were held at the Engineers' Club during the year. The total number of members and guests served with suppers was 318, an average of 64 per meeting. This average is less by 17 than for the previous year. An average of 9 additional persons attended the meetings following the supper.

One hundred and fifteen members and guests attended the Annual Dinner at the Chamber of Commerce Building. This was 13 less than for the previous Annual Meeting. One hundred and eighty-nine were served at the Student Night meeting in October in the Walker Memorial at M.I.T. This meeting included the Student Chapters of the American Society of Civil Engineers at Harvard, Tufts, M.I.T., Brown, Rhode Island State, New Hampshire State, Worcester Polytechnic Institute, and the Northeastern University Section of the Boston Society of Civil Engineers. The attendance at the meeting following the supper was increased to a total of 225.

A summary of attendance at the various meetings follows:

		Attendance	
		Dinners	Total
March 19, 1941	Chamber of Commerce	115	115
April 16, 1941	Engineers Club	100	125
May 21, 1941	New Lecture Hall Harvard Unversity	24	175
September 24, 1941	Boston City Club	70	70
October 15, 1941	M.I.T., Student Night	189	225
November 26, 1941	Engineers Club	58	68
December 17, 1941	Engineers Club	47	54
January 14, 1942	Engineers Club	54	58
February 18, 1942	Engineers Club	59	72
		716	962

The average attendance at meals for all nine meetings was 80. The average total attendance at the meetings was 107.

Respectfully submitted,

JOHN H. HARDING, *Chairman.*

REPORT OF THE COMMITTEE ON RELATIONS OF SECTIONS TO MAIN SOCIETY

Boston, March 18, 1942.

To the Boston Society of Civil Engineers:

The Committee on Relations of Sections to the Main Society reports that it has held no separate meeting during the year as a committee, but that its members have met from time to time with the Society officers and the Board of Government and have discussed frequently and at some length the business and interests of the various sections.

This committee reports that the Designers, Highway, Sanitary, Hydraulics and Northeastern University Sections have held regular meetings during the year. Because of the war situation and of the uncertainties as to attendance and as to speakers, several meetings were sponsored jointly by a section and by the Main Society. Better attendance than would be secured at either a separate section or society meeting was thus obtained and concentration on the securing of a few expert speakers was permitted. It was difficult to schedule speakers very far in advance of a meeting date, because of the changes in position taking place in the preparation for war, particularly amongst prominent engineers, which changes caused some cancellations of plans.

The holding of joint meetings was and is a proper society policy in times like these, as most of the attending members have been particularly busy on war work or work related thereto, with but little opportunity to join in Society activities, whether held by the sections or by the Main Society. The holding of meetings in the Society rooms by the Sections is a poor arrangement from many standpoints particularly because of lack of space, chairs, and speakers' facilities, and the holding of the joint meetings obviated the necessity for using the Society rooms by the sections on those occasions.

In spite of the diversity of attentions in this period of unrest, there has been an active and healthy interest by nearly all members in both section and Society affairs, and this committee recommends that the Society encourage a continuance of the joint meeting policy as long as present conditions exist. This policy is in preference to either of two other choices; namely, that of holding of many separate section meetings under undue difficulties as to speakers, attendance and quarters, or that of the curtailment of section activities or meetings.

Respectfully submitted,

STANLEY M. DORE, *Chairman.*

REPORT OF THE COMMITTEE ON WELFARE

Boston, March 16, 1942.

To the Boston Society of Civil Engineers:

During the past year the situation as regards engineering employment in this locality has been a very healthy one. In consequence of this condition, no matters pertaining to the welfare of members of the Society have come to the attention of the Welfare Committee for action and it has not been necessary for the Committee to hold any meetings during the year.

It has been customary to include in the report of this Committee a brief statement regarding the operations of the Emergency Planning & Research Bureau, Inc., as an indication of the employment situation. Placements by the "Bureau" during the year 1941 were 228 which is somewhat over 10 per cent in excess of the previous year and were the largest since the "Bureau" established a charge for placements. The year 1941 is the first year that none of the employment registrants have been on relief projects. Income from the placement activities of the "Bureau" amounted to nearly $5,000 in 1941, which is over 40 per cent in excess of the corresponding receipts for 1940. New registrants at the "Bureau" were somewhat less than in 1940 although the number of positions available increased by about 15 per cent above 1940. On December 31, 1941, the "Bureau" had registrations for employment of yearly 2,600.

Negotiations are now pending for the establishment of an office of the Engineering Societies Personnel Service, Inc., in Boston, to take over the activities of the Emergency Planning & Research Bureau, Inc. The Engineering Societies Personnel Service, Inc., is an agency of the four founder national engineering societies. The directors of Emergency Planning & Research Bureau, Inc., believe that present negotiations are favorable to the best interests of the employment service of the "Bureau".

It is recommended, as in the past, that members of our Society should take full advantage of the facilities for employment service which are now afforded by the "Bureau" and will be continued by Engineering Societies Personnel Service, Inc., if present negotiations are successfully carried out.

Respectfully submitted,

RALPH W. HORNE, *Chairman.*

REPORT OF THE LIBRARY COMMITTEE

Boston, March 11, 1942.

To the Boston Society of Civil Engineers:

The Library Committee engaged in its usual activity of maintaining the Society's library up to date with the selection and acquisition of new books. A complete list of books purchased or donated by publishers or authors is given below.

This committee also prepared for the Board of Government a "Report on Valuation of the Property and Library of the Society". The appraisal made for purposes of fire insurance was submitted on October 9, 1941.

The Library circulations for the year was 130 books.

Collection in fines amounted to $6.10.

The following books were purchased:

Webster's New International Dictionary of English Language (unabridged)
Hydraulic Measurements—Herbert Addison
Photoelasticity—Max Mark Frocht, Ph.D.
Engineering Materials and Processes—Metals and Plastics—William Howard Clapp, E.M., and Donald Sherman Clark, Ph.D.
Traffic Engineering Handbook—Harold F. Hammond and Leslie J. Sorenson
Civil Air Defense—Augustin M. Prentiss, Ph.D.
Proceedings of the Purdue Conference on Soil Mechanics and Its Applications. Sponsored by Society for the Promotion of Engineering Education, Purdue Univ.
Soil Mechanics—Dimitri P. Krynine
Air Transportation—Claude E. Puffer, Ph.D.
Air Photography Applied to Surveying—C. A. Hart
Relaxation Methods in Engineering Science—R. V. Southwell
Traffic Accidents and Congestion—Maxwell Halsey

The following books were donated:

Design of Modern Steel Structures—Linton E. Grinter. Gift of the publishers, MacMillan Publishing Co.
Experiments upon the Flow of Water in Pipes and Pipe Fitting—John R. Freeman. Gift of publishers, American Society of Civil Engineers.
Civil Engineering Handbook—L. C. Urquhart. Gift of John B. Babcock, 3d.
Erosional Topography and Erosion—James M. Little. Gift of the publishers, A. Carlisle & Co.
Sixty Year Index, A.S.M.E. Technical Papers—A.S.M.E. Gift of publishers, American Society of Mechanical Engineers.

Respectfully submitted,

Eugene Mirabelli, *Chairman.*

REPORT OF THE COMMITTEE ON SUBSOILS OF BOSTON

Boston, March 9, 1942.

To the Boston Society of Civil Engineers:

All members of the Committee on Subsoils of Boston have been intensely occupied with wartime projects so that they were not able to contribute directly to the work of this Committee. However, in connection with the many construction activities in the area of Greater Boston, extensive borings were carried out with improved sampling methods. These data form in themselves a substantial contribution to our knowledge of the subsoil conditions of Boston and should be digested and made available to the profession when more normal times again permit attention to such activities.

Respectfully submitted,

A. CASAGRANDE, *Chairman.*

REPORT OF THE COMMITTEE ON THE JOHN R. FREEMAN FUND

Boston, March 19, 1942.

To the Boston Society of Civil Engineers:

On account of unsettled conditions of the world, and the demand for more important tasks than would be required for experimental problems in hydraulics, it has been impossible to undertake the problems anticipated under the awards of last year from the Freeman Fund.

The Committee has, therefore, decided not to make any scholarship awards for this year. It has approved, and payment has been made, for the cost of a portion of the preparation of the report of the Flood Committee amounting to $116.87, and it approves the payment of the full cost of the printing of the valuable report of the Flood Committee estimated to cost about $650.

It is estimated that there will be available from the Fund, from the balance on hand and the income during the coming year, about $2,500.

For the Committee,

CHARLES T. MAIN, *Chairman.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION

Boston, March 4, 1942.

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year six meetings have been held and papers were presented as follows:

March 5, 1941.—"Sanitation—Southern Style" by Professor Gordon M. Fair, Professor of Sanitary Engineering, Harvard University.

April 2, 1941.—"Grease Recovery from Industrial Wastes" by George G. Bogren, Sanitary Engineer, Weston & Sampson, Consulting Engineers.

May 17, 1941.—Inspection trip to new sewage treatment plant at Cranston, Rhode Island, and U. S. Naval Air Station at Quonset Point, Rhode Island.

October 1, 1941.—"Water Supply in Venezuela" by J. R. Snell, Consulting Engineer.

December 17, 1941.—Joint meeting of the Boston Society of Civil Engineers with the Sanitary Section. "Delaware Water Supply System" by Roger W. Armstrong, Deputy Chief Engineer, Board of Water Supply of New York City.

January 7, 1942.—"The Operation of the Wards Island Sewage Treatment Plant" by Gail P. Edwards, Principal Sanitary Chemist, Wards Island, New York.

Attendance at the meetings has varied from 22 to 54, and has averaged 43. Executive Committee meetings have been held prior to each section meeting.

Respectfully submitted,

For the Executive Committee,

WALTER E. MERRILL, *Clerk.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE DESIGNERS' SECTION

Boston, March 9, 1942.

To the Designers' Section, Boston Society of Civil Engineers:

The following is a list of the meetings which were held during the year, March, 1941 to March, 1942:

March 12, 1941. Annual meeting and election of officers. Mr. Wesley H. Blank spoke on the "Analysis of Rigid Knee Braced Bents and Application to Chemical Plant Design." Attendance, 20.

April 9, 1941. Professor Joseph S. Newell spoke on "Structural Problems in Airplane Design." Attendance, 36.

May 14, 1941. Mr. William P. MacDonald spoke on "The Design of Supporting Structures for Heavy Building Cranes." Attendance, 45.

October 8, 1941. Mr. James H. Carr, Jr., spoke on "Recent Developments in Timber Engineering." Attendance, 46.

November 12, 1941. Mr. Edmund M. Burke talked on "Plant Facilities Expansion at Fore River Shipyard." Attendance, 40.

December 10, 1941. Commander H. E. Rossell spoke on "Structural Problems in Ship Construction." Attendance, 26.

January 14, 1942. This was a joint meeting with the Boston Society of Civil Engineers. Professor Roy W. Carlson spoke on the subject of "Cracks in Concrete." Attendance, 58.

February 11, 1942. Col E. J. W. Ragsdale spoke on "Structural Designing for Thin Walled Sections." This was the third of a series of talks indicating various typical philosophies of structural design. This was a joint meeting with the Highway Section, Boston Society of Civil Engineers. Attendance, 27.

The total attendance at the meetings was 298. The average attendance was 37.

Respectfully submitted,

HERMAN G. PROTZE, *Clerk.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE HIGHWAY SECTION

Boston, March 18, 1942.

To the Highway Section, Boston Society of Civil Engineers:

During the past year the Section held the following meetings:

October 22, 1941. Mr. Frank Crandall, Assistant Engineer, Liberty Mutual Insurance Company, spoke on "Defense Construction Methods and Progress in other parts of the Country." Attendance, 25.

November 26, 1941. Joint meeting with Main Society. Charles M. Upham, Engineer Director of the American Association of Road Builders, spoke on "Post War Highway Economics". Attendance, 68.

March 18, 1942. Annual meeting. Election of officers.

Respectfully submitted,
For the Executive Committee,

HERMAN S. SWARTZ, *Chairman.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE HYDRAULICS SECTION

Boston, March 11, 1942.

To the Hydraulics Section, Boston Society of Civil Engineers:

During the past year the section held the following meetings:

May 7, 1941. Society Rooms. Speakers: Howard M. Turner, Consulting Engineer, and Allen J. Burdoin of Metcalf & Eddy. Subject: "Flood Hydrographs". Attendance, 34.

November 18, 1941. Society Rooms. Speaker: Karl R. Kennison of the Boston Metropolitan District Water Supply Commission. Subject: "The Hydraulics of the New Pressure Aqueduct of the Metropolitan Water District." Attendance, 37.

February 18, 1942. Engineers Club. Speaker: W. C. Hoyt. Subject: "Unusual Features of Floods in the United States." Attendance, 72.

The total attendance of the meetings was 143. The average attendance was 48.

Respectfully submitted,

HAROLD A. THOMAS, JR., *Clerk.*

REPORT OF THE EXECUTIVE COMMITTEE OF THE NORTHEASTERN UNIVERSITY SECTION

Boston, March 2, 1942.

To the Northeastern University Section, Boston Society of Civil Engineers:

During the past year this Section has held the following meetings and field trips:

March 21, 1941. Mr. James H. Mooney, Building Commissioner, City of Boston, described "Building Department Organization and Building Laws." Attendance, 40.

April 25, 1941. Thirty-two students journeyed to the Fourth Annual New England Conference of Student Chapters of the American Society of Civil Engineers at Brown University.

May 9, 1941. Mr. T. A. Berrigan, Deputy Chief Engineer of the Sewage Division of the Metropolitan District Commission of Massachusetts, discussed "The Engineer and the Law." Attendance, 45.

May 21, 1941. Mr. Warren Boutelle, student at Northeastern University, presented a paper entitled "Sewage Treatment at Camp Edwards." Following the talk, election of officers for the year 1941-1942 was held. Attendance, 37.

October 3, 1941. Gordon M. Fair, Professor of Sanitary Engineering, Harvard Graduate School of Engineering, spoke to the Section on "Sanitation Southern Style." Attendance, 52.

October 15, 1941. Sixty Section members attended the Student Night sponsored by the Boston Society of Civil Engineers and the Northeastern Section of the American Society of Civil Engineers at Massachusetts Institute of Technology.

October 23, 1941. Mr. Norman S. Crossley, student at Northeastern University, presented a paper entitled "Construction of Reinforced Concrete Drawbridge." Attendance, 34.

November 1, 1941. A field trip was made by Division "A" to the Franklin Falls Dam on the Pemigewasset River, Franklin, New Hampshire. Attendance, 26.

November 7, 1941. Mr. Louis H. Berger, President of C. L. Berger & Sons, Inc., addressed the group on "Simplicity of Design, Materials Suitable for Construction, and the Proper Care of Engineering and Surveying Instruments." Attendance, 29.

December 4, 1941. Mr. John Cusack, Student at Northeastern University, presented a paper on "Embankment Control at Franklin Falls Dam." Attendance, 44.

December 5, 1941. Mr. Robert A. Prowse, Engineer with Highway Bridge Department of the State of New Hampshire, spoke on "Designing Time Two Hundred Years." Attendance, 48.

January 9, 1942. Mr. Clarence B. Humphrey, Engineer for Land Court, addressed the Section on the "Massachusetts Land Court." Attendance, 44.

February 6, 1942. Showing of slides and films, and reading of lecture on the collapse of the Tacoma Narrows Bridge. Attendance, 76.

February 10, 1942. Mr. Anthony Bennedetto, student at Northeastern University, presented a paper on "Timber Pile Foundations." Attendance, 35.

February 17, 1942. Mr. Allan Levy, student at Northeastern University presented a paper on "The History of Boston's Datum Plane." Attendance, 28.

A meeting of the Executive Committee of the Section was held regularly each week.

The total attendance at meetings and trips was 630, ranging from 26 to 76. The average attendance was 42.

Respectfully submitted,

IRVING T. BERKLAND, *Clerk.*

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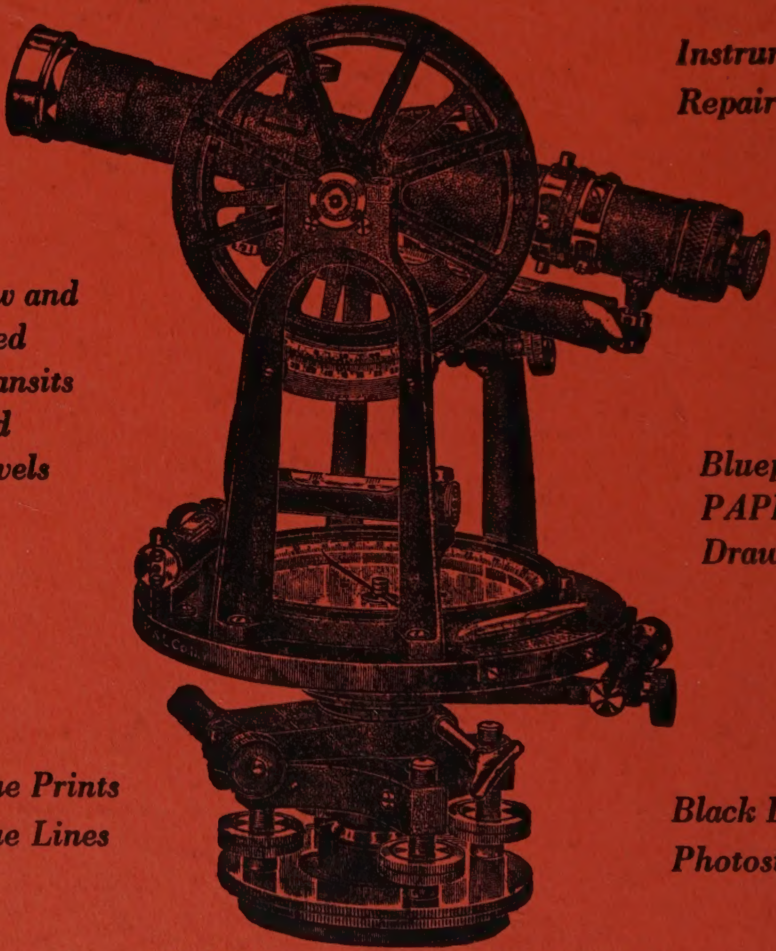

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